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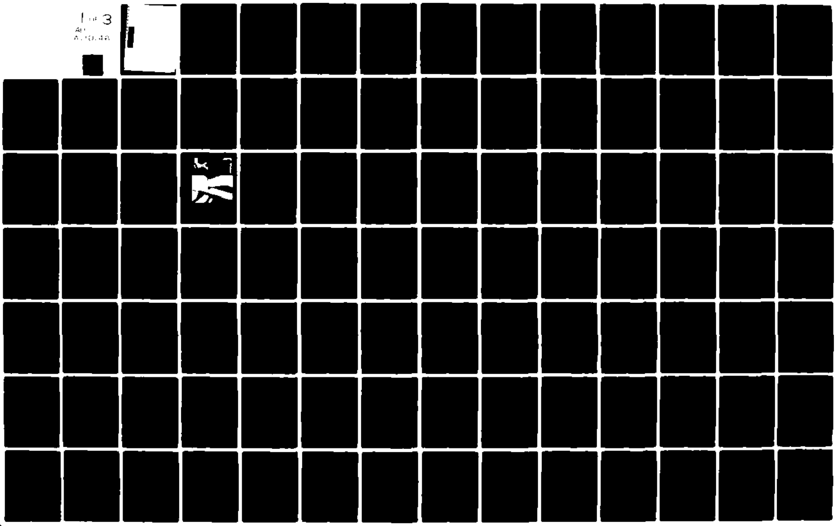

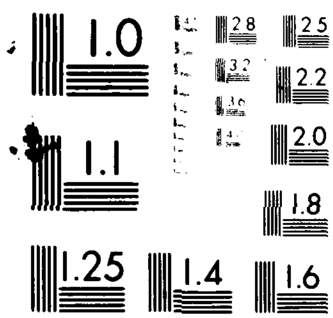

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The overall objectives of this report are to assess the impact, both positive and negative, of Corps of Engineers' activities on Pool 3 (Red Wing, Minnesota) of the Upper Mississippi River. An analysis of natural and socioeconomic systems is included. The natural systems include terrestrial and aquatic plant and animal life, the nature of the land and water quality. Socioeconomic systems include industrial and recreational activities, and cultural considerations, including archaeological and historical sites.

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FINAL REPORT

ENVIRONMENTAL IMPACT ASSESSMENT STUDY

POOL 3

of the Northern Section of the UPPER MISSISSIPPI RIVER

for the

ST. PAUL DISTRICT CORPS OF ENGINEERS
Under Contract No. DACW37-73-C-0059

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November 1973

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FOREWORD

PURPOSE OF THE ENVIRONMENTAL STUDY

The National Environmental Policy Act of 1969 (NEPA) directs all agencies of the Federal Government must "include in every report on proposals for legislation and other major Federal actions significantly the quality of the human environment, a detailed statement... on the environmental impact of the proposed action". The NEPA Act deals only with proposed actions of the Federal Government. The U.S. Army Corps of Engineers developed its own policy in keeping with the spirit of the Act, in that it requires such an environmental report on projects which have been completed, but which require continued operational or maintenance activities.

In keeping with the policy, the Saint Paul District of the Corps of Engineers contracted with North Star Research and Development Institute to prepare an environmental impact assessment report on the Corps of Engineers operating facilities and operations on the Mississippi River from the head of navigation in Minneapolis, Minnesota to Guttenberg, Iowa. Included are waters from Shakopee, Minnesota, on the Minnesota River; and waters downstream from Stillwater, Minnesota, on the St. Croix River to their respective junctures with the waters of the Mississippi River. This area of the Mississippi River, and the included areas of the Minnesota and St. Croix Rivers, will be termed the "Northern Section" of the Upper Mississippi River or the "study area".

The Corps of Engineers has been active within the Northern Section since ca. 1820, when they were instrumental in clearing navigation impediments such as brush and snags to Fort Snelling, (Minneapolis/St. Paul). Beginning in the 1870's, further actions by the Corps included construction of wing dams along with channel maintenance and dredging. Presently, the study area has become a set of pools which were created by the construction of locks and dams for navigational advantages in the decade of the 1930's. A few recreation areas were also built by the Corps.

The purpose of this environmental impact study, is to assess the positive as well as negative impacts of the Corps' activities on the Northern Section of the Mississippi River. For the scope of this study, the "Activities" of the Corps shall be delimited to those actions involved in the main channel maintenance (dredging), and the operation of the navigational facilities (locks and dams). Though there are some recreational activities by the Corps, and that there were other activities by the Corps not directly involved in the preceding two limitations, the impacts involved in these actions will be of secondary interest. Current actions by the Corps shall receive prime attention.

The studies herein described, are designed to include impacts upon social as well as natural environment. Effects of dredge spoils on recreational and natural areas, the effect of the pools as created by the dams, the effects of river navigation/transportation on community

economy, are all areas of impacts within the study. The identification and assessment of the impacts will aid in the determination of methods to intensify the positive impacts, and to decrease the negative effects of Corps activities. The study should provide a comprehensive basis for the Saint Paul District to prepare an environmental impact statement to comply with the requirements of the National Environmental Policy Act of 1969, and the current policy of the Corps of Engineers.

SCOPE OF THE CURRENT REPORT

This report concerns information of a current nature as already known by the various principal investigators, information of a historical nature which was readily available from various Federal, State and private agencies. It also contains results of fieldwork carried out during the time period of this study, and alludes to portions of fieldwork which were planned, but not completed due to the severe time limitations placed upon the study. The time encroachment became especially detrimental to the fieldwork, in that insufficient time was available for data analyses subsequent to the conclusion of field collecting.

RESEARCH APPROACH

Three aspects of the approach used in this study will require clarification: (1) the time benchmark; (2) data collection and the subsequent analyses, (natural systems); (3) data collection and analyses, (socioeconomic systems).

Time-Period Benchmark

To analyze the impact of the Corps' activities on the Northern Section of the Mississippi River, it became necessary to select a limited time-period to serve as a bench-mark. This bench-mark serves as an indication of the condition of the Mississippi River prior to construction of the Nine-Foot Channel Project of the 1930's. The pre-construction bench-mark is arbitrarily taken as 1930. Wing Dam construction and other Corps activities certainly left an impact upon the Mississippi prior to 1930, and these data are used as they are available and as they may apply to subsequent actions of the Corps. These data were obtained from available sources, and are cited in Appendix A.

Analysis of Natural Systems

The impact of the Corps' activity on the natural environment of any one pool is determined by the individual principal investigator responsible for that particular pool. The Northern Section of the Upper Mississippi River was subdivided into fourteen distinct segments for purposes of this study of the natural environment: Pools 1 through 10, Pool 5A (located between Pools 5 and 6), the Upper and Lower Saint Anthony Falls (SAF) Pools - (a single report for both Pools), the Minnesota River, and the Saint Croix River. Each segment was assigned to an individual investigator on the natural sciences team. The responsibilities are underlisted:

Number of River Segments Involved	River Segment	Responsibility	Organization
5	Upper & Lower SAF Pools, Pool #1, Pool #2, Minnesota River, and St. Croix River	Roscoe Collingsworth	North Star Research & Development Institute
1	Pool #3	Edward F. Miller	North Star Research & Development Institute
4	Pools #4, 5, 5A, and 6	Calvin Fremling	Winona State College, Winona, Minnesota
2	Pools #7 & 8	Thomas Claflin	University of Wisconsin, LaCrosse, WI
1	Pool #9	James Eckblad	Luther College, Decorah, Iowa
1	Pool #10	Edward Cawley	Loras College, Dubuque, Iowa

Because each segment of the river presents its own unique set of problems, each investigator was to use his own judgement in conducting the studies under his responsibility. North Star Research and Development Institute acted as a coordinator in developing general guidelines for conducting field studies with the cooperation of the investigators. The conduction of field studies, acquisition of data, and the presentation of the final report were all outlined in a generalized format to increase the utility of the combined reports by future users of the overall report.

Analysis of Socio-economic Activities

The socioeconomic study for all pools in the study area were conducted by a team including Dr. C. W. Rudelius of the University of Minnesota and W. L. K. Schwarz of North Star Research and Development Institute. The socioeconomic impacts were analyzed by the same team for all fourteen of the earlier cited segments of the Northern Section because substantial economies in data collection were possible with this approach. The initial data for each pool were collected and then were submitted to the investigator analyzing the natural systems for that particular pool. The suggestions of these investigators were incorporated into the socioeconomic portions of each pool report.

REPORT OBJECTIVES

Since the Corps of Engineers is required to submit a statement for each pool and tributary in the Northern Section on which they carry out operation and maintenance activities, it seemed most practical to carry out this initial study by pools.

The present report deals only with Pool #3, on the Upper Mississippi River, which is described on the following pages. Other reports on other pools in this series of investigations, will be submitted by the responsible investigator. This report on Pool #3 must be capable of standing alone, but the reader should understand that pages 1 and 2 of this report are very similar to the initial pages of all of the reports. The similarities are unavoidable in that we are studying

a single river.

The overall objectives of this report are to identify and to provide an assessment of the impacts of the Corps of Engineers' activities related to Pool #3. Following this section, the report seeks to:

1. Identify the environmental, social, and economic impacts of the Corps activities related to Pool #3.
2. Identify and if possible, measure beneficial contributions, and the detrimental aspects of these impacts and draw overall conclusions about the net effects of the Corps' activities.
3. Recommend actions and possible alternative methods of operations that should be taken by the Corps of Engineers, other public agencies, and private groups, to reduce the detrimental aspects of the project.
4. Identify additional specific research needs to assess the impacts, and to increase the beneficial aspects of the Corps' operations.

The report includes an analysis of the natural and socioeconomic systems. The natural systems includes terrestrial and aquatic plant and animal life, as well as the nature of the land and the quality of the water. Socioeconomic systems includes industrial activities as income and employment generated by barge traffic or activities of operating the locks and dams; recreational activities as fishing, boating, or hunting that are related to Corps activities; and cultural considerations, which include archaeological and historical sites. A

major portion of the localized historical information in Pool #3 were made available through the assistance of Kenneth Krumm.

1. PROJECT DESCRIPTION

The project consists of structures, and operation and maintenance activities. Its structures include: (1) 133 wing dams built during the 1870's through 1910; (2) a low-head, movable crest dam with a navigational lock; (3) 13.5 miles of riprap bank protection (underwater); (4) one picnic area.

Operations include reservoir control of water levels, and locking operations of Lock and Dam #3. Emergency operations are incorporated during flood emergencies.

Maintenance includes the navigation channels and harbors to the required nine-foot depth, disposition of dredge spoils, clearing debris within and near the navigational waterways, and maintaining the dredging equipment and lock and dam in good operating condition.

AUTHORIZATION

The series of Congressional authorizations for construction, operation and maintenance of a nine-foot navigation channel by the Corps, began with the Rivers and Harbors Act of September 12, 1922. The Rivers and Harbors Act of 1930 and as amended in 1932, provided for extension of the channel to Minneapolis. Many additional acts have provided for harbors, snagging, etc. The construction of Lock and Dam #3 was in the approved program for public works under the Emergency Relief Act of April 8, 1935.

HISTORY

In 1824, Congress authorized the Corps of Engineers to improve navigation by removing obstructions to navigation such as: sandbars, shoal, wrecks and snags.

The first serious improvement of the river was begun under the authority of the Rivers and Harbors Act of June, 1878, which was to create a 4.5 foot channel from St. Louis to St. Paul. The method of making and holding the four and a half foot channel was to be through the construction of wing-dams, underwater bank protection closing dams and longitudinal dikes.

Figure one illustrates that portion of the Mississippi known as Pool #3, (796.9 through 815.2 miles), which is located between Lock and Dam #2, and Lock and Dam #3, where many wing-dams and bank revetment were constructed. The function of the wing-dams was to direct the current towards the center of the main channel, while the revetment (reprapping) was to protect the shore from washouts due to wave action resulting from boat traffic. The several sharp changes in direction of the river, plus the confluence of the St. Croix River, required these structures. The majority of the wing-dams and bank protection are still present, but are primarily underwater and have undergone modifications through damage, and/or restructuring. The manner of construction of the wing-dams is seen in Figure two, while the construction of the bank revetments is shown in Figure three. The alternating bundles of willows and layers of rock have withstood the 60-plus years very well. The

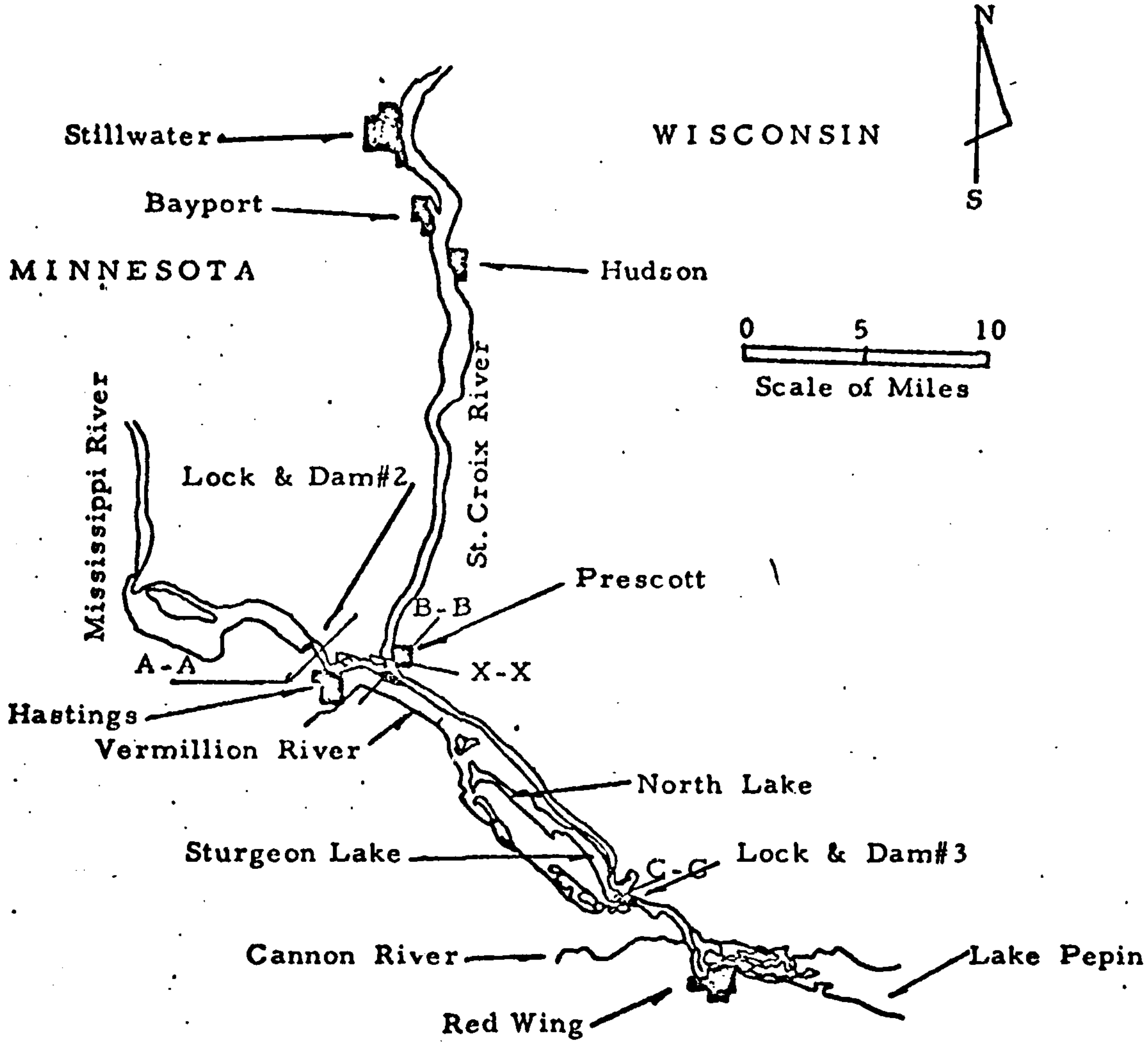

Figure 1. Location of Pool Three and the Standard Transects (A-A etc.).

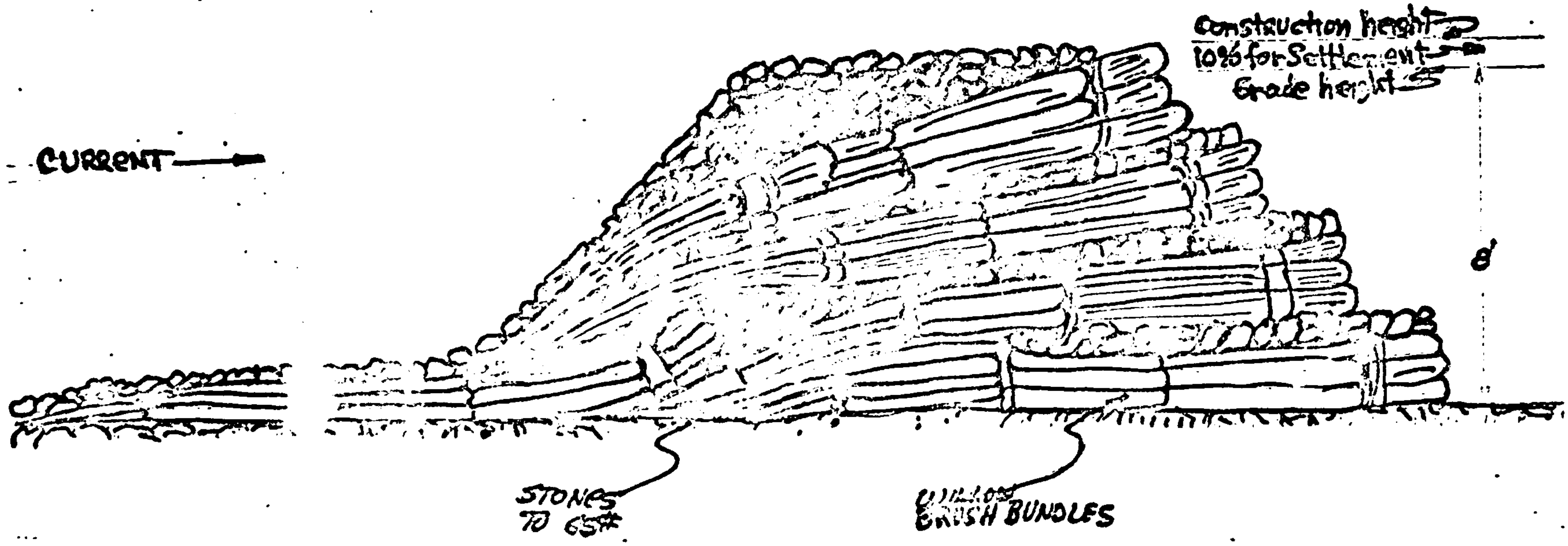

Figure 2. Cross-section of a typical wing dam construction on the Mississippi River during the years 1880-1899. (Supplied by U. S. Army Corps of Engineers)

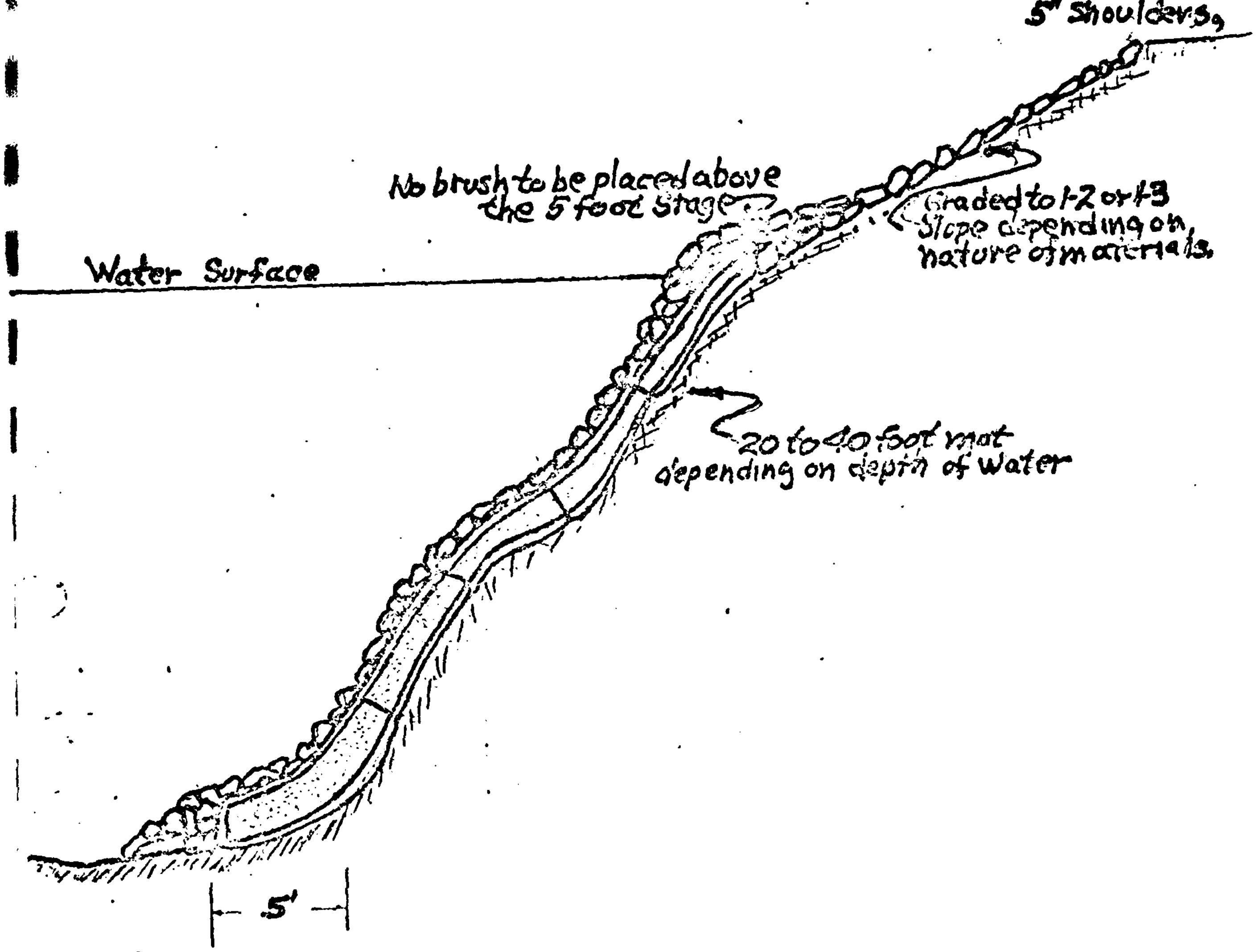

Figure 3. Cross-section of a typical underwater bank-protection mat (Rip-rap) constructed on upper Mississippi River during the years 1880-1900. [Supplied by U. S. Army Corps of Engineers (slightly redrawn)].

upper sections of the bank revetments have been undermined and collapsed due to ice actions and inundation at a higher water level than originally designed for.

The Mississippi River Commission had the Corps publish a series of charts (MRC Charts) showing river depths, bed types and land uses during the period 1894 to 1907.

A six-foot channel was authorized in 1907, which was accomplished through the construction of wing-dams and maintenance dredging. The results of this project was surveyed and photographed during 1927, and published as the "Brown Survey". The aerial photographs are still in existence, and were used in partial analysis of this report. The "flowage charts" of 1933-34 were constructed from the Brown Survey, and were used to illustrate land use.

The current project, the nine-foot channel and its associated structures, was constructed in the early 1930's. Beginning in 1933, and completed on March 30, 1938; the Lock and Dam #3 went into operation July 21, 1938. Full pool was reached August 12, 1938, after being held at a lower elevation to allow road construction. The normal pool elevation of 675.0 is maintained at primary control point at Prescott, Wisconsin. The secondary control point is the Dam #3, which currently is permitted a maximum of a one-foot drawdown.

CORPS FACILITIES

Lock and Dam #3 is located 796.9 river miles above the mouth of the Ohio River. It is the fifth Lock and Dam downstream from the head of navigation. Lock and Dam #3 (L/D#3) is located 18.3 river miles downstream from L/D #2 at Hastings, Minnesota, and 6.1 river miles upstream from the city of Red Wing, Minnesota. The next Lock and Dam structure downstream is L/D #4 at Alma, Wisconsin, a distance of 44.2 river miles. The main lock and the completed upstream section of the auxiliary lock are located on the right or Minnesota bank of the main channel of the Mississippi River. A 2,400 foot dike section extends landwards from the lock and ties into the alluvial terrace upon which is located the roadbed of the Chicago, Milwaukee, St. Paul and Pacific Railroad.

The upstream end of an island forms an embankment that separates the locks from the movable dam section consisting of four 80-foot roller gates. There are no Tainter Gates in this dam. There is another dike section reaching about 1,475 feet towards the Wisconsin shore of the main channel. The Wisconsin shore consists primarily of low-lying ground forming a series of old "ox-bows" remaining from former channel meandering prior to influence by the Corps of Engineers. To help stabilize these old "channels" during inundation by flood waters, a series of ten "spot-dikes" (labelled A through J) and two sag-dikes were constructed during the construction of Lock and Dam #3. The various locations of these auxiliary dikes extend about three

miles upstream from the main lock and dam.

The entire structure of L/D #3 is designed for a lift of 8-feet which provides a depth of nine feet in the pool created upstream towards L/D #2. General location of L/D #3 is shown in Figures 1 and 4, while the second page of Figure 4 illustrates the overall construction of L/D #3.

Features of the Pool #3 include the characteristics outlined in Table 1. Pool #3 is the fifth largest of the pools in the St. Paul District, extending from L/D #3 upstream 18.3 miles to L/D #2; and about 33 miles upstream into the St. Croix River. The St. Croix portion is NOT covered in the remainder of this paper, as it will be described for the Corps of Engineers by Roscoe Colingsworth, (1973).

In the Mississippi River Valley below the juncture of the St. Croix, the pool widens and spreads over areas typical of a low, flat-bottomed, wide flood-plain. The lock, dam-site, and channed lies between high bluffs which outline the valley. The numerous coulees give the area a semi-hilly aspect when viewed from the water-surface of the Mississippi River. Going upstream from L/D #3, the channel describes an elongated "S" curve moving to the Wisconsin shore and paralleling the Chicago, Burlington and Quincy Railroad bed most of the distance until the channel crosses to the Minnesota side again near Hastings, Minnesota. This channel directional pattern places most of the above-water project-lands on the Minnesota side.

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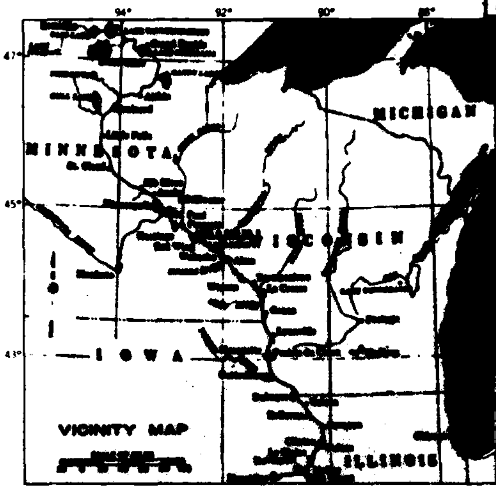
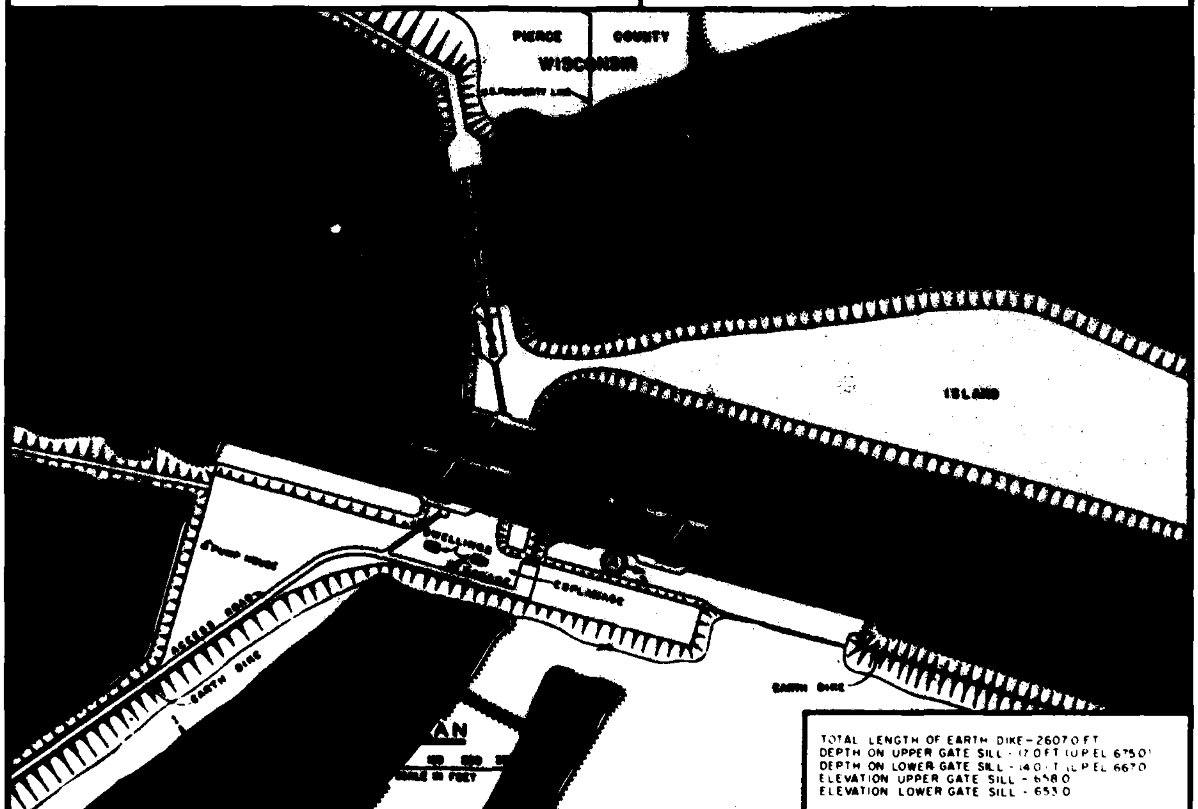




TOTAL LENGTH OF EARTH DIKE - 2607.0 FT
DEPTH ON UPPER GATE SILL - 17.0 FT (U.P. EL 675.0)
DEPTH ON LOWER GATE SILL - 14.0 FT (L.P. EL 667.0)
ELEVATION UPPER GATE SILL - 658.0
ELEVATION LOWER GATE SILL - 653.0

Figure 4A

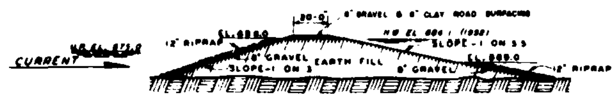
ELEVATIONS ARE REFERRED TO M.S.L. (1912 ADJ.)

RIVER & HARBOR PROJECT
MISSISSIPPI RIVER
MISSOURI RIVER TO MINNEAPOLIS, MINN.

LOCK & DAM NO. 3

IN 2 SHEETS SHEET NO. 1
SCALE AS SHOWN

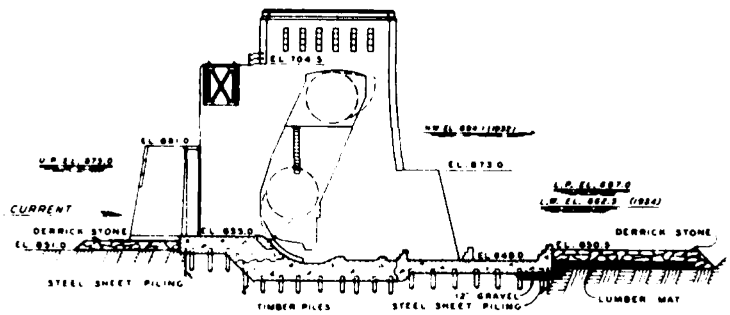
CORPS OF ENGINEERS U.S. ARMY
OFFICE OF THE DISTRICT ENGINEER
ST PAUL DISTRICT ST. PAUL, MINN
JUNE 1961



SECTION C-C

EARTH DIKE

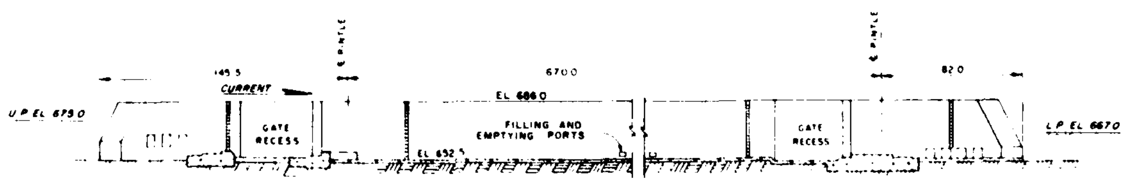
20 0 20 40 60
SCALE IN FEET



SECTION B-B

ROLLER GATE

10 0 10 20 30
SCALE IN FEET

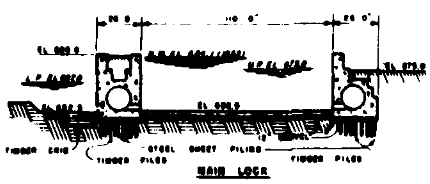


SECTION X-X

MAIN LOCK

20 0 20 40 60
SCALE IN FEET

ELEVATIONS ARE REFERRED TO M S L (1912 ADJ)



SECTION A-A

LOCK

20 0 20 40 60
SCALE IN FEET

Figure 4B

RIVER & HARBOR PROJECT
MISSISSIPPI RIVER
MISSOURI RIVER TO MINNEAPOLIS, MINN.

LOCK & DAM NO. 3

IN 2 SHEETS SHEET NO 2
SCALE AS SHOWN

CORPS OF ENGINEERS U S ARMY
OFFICE OF THE DISTRICT ENGINEER
ST PAUL DISTRICT ST PAUL, MINN
JUNE 1961

There are about 5,680 acres held by the Federal Government within the confines of Pool #3. There are 5,612 acres under jurisdiction of the Corps, while the U. S. Department of Interior, Bureau of Indian Affairs has jurisdiction over 68 acres directly within the Pool line. As Government-owned lands are located in the Mississippi River portion of the overall Pool #3. The Minnesota Department of Natural Resources leases 3,742 acres of lands, titled to the Corps of Engineers, as the Gores Wildlife Management Area.

Table 1. Principal physical and other features of Pool #3, Mississippi River.

Length of pool	Mississippi River St. Croix River	18.3 river miles 33.0 river miles
River Miles	Mississippi River St. Croix River	796.9 to 815.2 0 to 33.0
Pool Elevation (flat pool)		675.0
Water area of pool (Mississippi River, July, 1967)		17,950 acres
Primary shore line (Mississippi River)		37.1 miles
Federal lands above normal flat pool (approximate)		
ad[illegible]gineers		3,430 acres
administered by Department of Interior		68 acres
Total above-water lands		3,498 acres

CORPS OPERATION AND MAINTENANCE

The project at this time, consists primarily of the operation

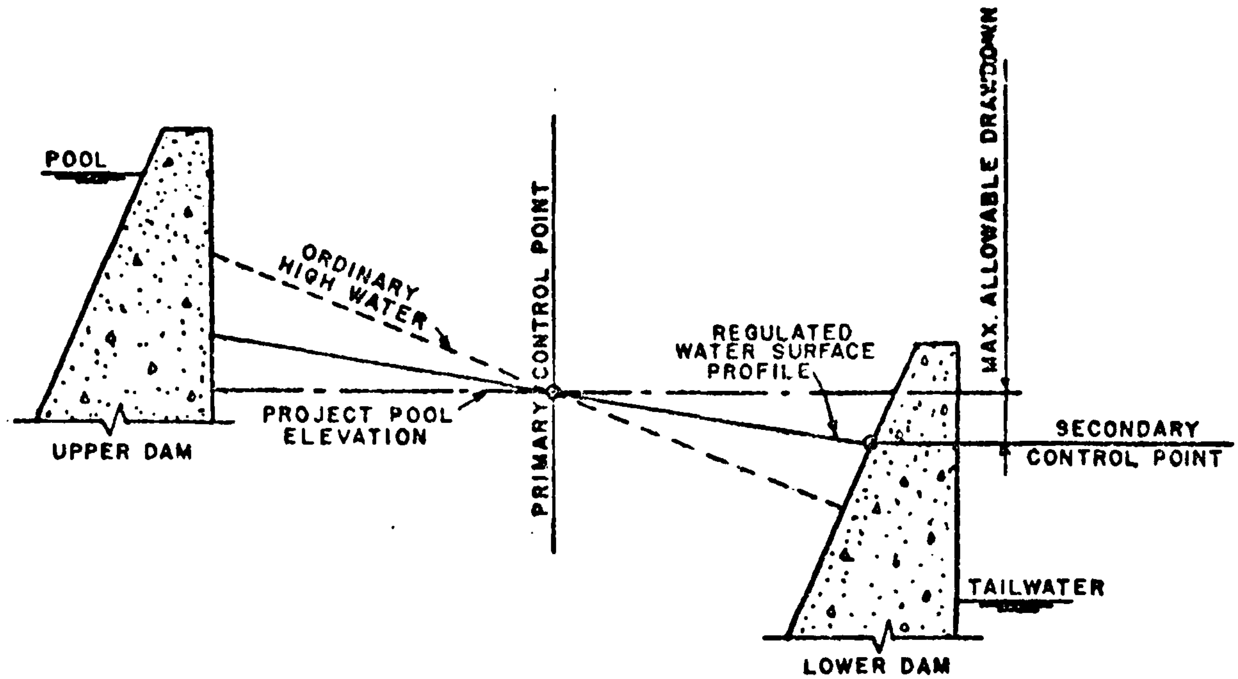


Figure 5. Basic plan of control for a navigation pool on the Mississippi River.

and maintenance of Lock and Dam #3, and the continual job of maintaining a nine-foot navigational channel through dredging and alterations of wing and closing-dams. The relatively low height of the dam and the low head resulting, preclude use of the structure for either power production or flood control. The nine-foot channel is maintained at a 200' minimum channel width. The Corps also dredges small-boat harbors, constructs flood levees, and directs flood protection activities as secondary considerations to the nine-foot channel project, in cooperation with local community authorities.

Lock and Dam Operations

Lock and Dam #3 was constructed with a low head in order to minimize the flooding of adjacent low-lying lands. The control point of Pool #3 is at Prescott, Wisconsin with a flat-pool level of 675.0 as measured at the gauge at Prescott, (Mean Sea Level, 1912 datum). The original drawdown of Pool #3 was set at two feet, but has since been limited to a one-foot drawdown to minimize effects upon the fishery and wildlife nesting.

If no flow was present in a particular pool, the pool would lie flat through its entire length. As the discharge enters the upper portions of the pool, that portion of the pool rises creating a slope. Since the control point of a pool is that portion of the pool regulating the overall pool elevation, it is located somewhere near the center of the pool relative to its length. The effects of upstream

rise due to increase in discharge and the resulting changes, are shown in Figure 5. The minimum drawdown of Pool #3 must be maintained to limits in order not to damage navigation or conservation management practices.

The water tends to pivot around the control point for each pool due to these Corps manipulations based upon upstream discharge considerations. The "high water mark" illustrated in Figure 5, is defined through the court decisions as that point up to which the presence and action is so continuous as to destroy the value of the land for agricultural practices by preventing the growth of vegetation. On navigable lakes and rivers, the Federal Government holds easement to use of the reparian lands up to the ordinary high water mark in the public interest.

When a maximum drawdown is accomplished, the control of pool water level is shifted to the dam. The pool is then said to be in secondary control. While in secondary control, increase of the dam discharge is carried out to keep the drawdown at maximum. If the tailwaters of the dam approach the depth of the upper pool waters by a foot, the roller gates are raised completely out of the water, and the river is said to be in open flow. These actions are carried out during flood periods, and are reversed as the flood waters subside.

The main reason for utilizing this method of water-level control, was to reduce the Governmental costs created by inundating terrestrial

property. With the pivot method around the mid-pool control point, only the lower half of the pool is greatly affected by Corps operational practices at the dam.

A priority system has been established by the Secretary of the Army, for vessels locking through. Though there seems to be no solid basis in law for this action, the priority as established is:

1. U. S. Military Vessels
2. Vessels carrying U. S. Mail
3. Commercial passenger ships
4. Commercial tows
5. Commercial fishing boats
6. Pleasure boats

Pool #3 is located about 21 to 39 miles downstream of the Minneapolis/St. Paul Sanitary District (MSSD), and receives a substantial amount of wastewater from the Twin City area (See Figure 6, and Table 2). Though a concerted effort has been ongoing to alleviate sewage loads, the effects are still noticed at the upper ends of Pool #3. The remainder of the pool is classified as a biological recovery zone, (Miller, 1971, 1972). The cooperation between the MSSD and the Corps through modification of the gates at Lock and Dam #3 has brought about significant increases in the assimilative capacity of the Mississippi River downstream. The Corps, the University of Minnesota and the MSSD bulkheaded four of the Tainter Gates at L/D #2

permitting a minimum of 3,000 cfs of water to flow through at all times. Subsequent to 1963, and after the floods of 1965 (record flood), and 1969 (second flood of record), the water quality has improved to the point of changing the designation of Pool #3 from a polluted pool to one of a recovery-zone pool. Studies during the past few years by Northern States Power Company and Edward F. Miller, has tended to indicate that Pool #3 may be changing into a "Clean-water" pool, in that identification of many pollution sensitive macroinvertebrates in well established populations is now easily demonstrable in the downstream portions of the pool (Miller, 1973).

Channel Maintenance and Harbor and Levee Construction

The river channel requires intermittent dredging to insure the nine-foot minimum depth, since retention of water by the dam is not enough. During the year, the ability to retain the sediment load, varies with current velocity and turbulence. The river then drops its sediment in areas which may be a portion of the navigational channel, which in turn necessitates dredging by the Corps of Engineers. These hazards to navigation are removed by the hydraulic dredge known as the THOMPSON which is operated by the Corps. It is based at Fountain City, Wisconsin, and has been in operation since 1937. In the event that dredge areas are too numerous to be handled efficiently in the season by the THOMPSON, contracts may be given to private dredging concerns to help clear the hazards. Table #3, and Figure #7 illustrate the extent of dredging within Pool #3 from 1938 through 1971.

Table 2. Major Wastewater Contributors to Minnesota/Mississippi Rivers Upstream of Pool Three of the Mississippi River

Wastewater Contributor	River Mile	Discharge Rate M Gal/Day
MINNESOTA RIVER		
Honeymead Products Company	109.2 (Blue Earth 0.6)	4,300
Mankato Sewage Treatment Plant	106.5	4,540
Archer Daniels Midland Compan	106.0	42
Blue Cross Rendering Company	105.5	94
NSP (Wilmarth Power Plant	105.2	33,120 (Max)
Green Gient Company	75.4	230
City of Henderson	70.0	40
Minnesota Valley Milk Producers Cooperative Association	49.8	270
Chaska Sewage Treatment Plant (includes Gedney Company Wastes)	29.4	460
American Crystal Sugar Company	27.7	7,000
Rahr Malting Company	25.4	2,800
Shakopee Sewage Treatment Plant	23.9	311
Owens-Illinois Forest Products	20.9	20
American Wheaton Glass Company	20.7	200
Savage Sewage Treatment Plant	14.4	215
Cargill, Inc.	13.4	3,320
Burnsville Sewage Treatment Plant	10.5	510
NSP Blackdog Power Plant	8.4	371,520 (Max)
MISSISSIPPI RIVER		
Anoka Sewage Treatment Plant	871.5	957
Cornelius Manufacturing Company (Rum R. 0.8)	871.4	125
Minneapolis Water Treatment Plant	858.7	2,300
NSP Riverside Steam-Electric Generating Plant	856.9	592,560 (Max)
NSP High Bridge Steam-Electric Generating Plant	840.5	449,280 (Max)
Minneapolis-St. Paul Sanitary District Sewage Treatment Plant	836.3	188,600
Swift and Company	833.4	5,000
Union Stockyards	833.2	2,000
Armour and Company	833.0	2,400
King Packing Company	832.5	1,730
South St. Paul Sewage Treatment Plant	832.4	14,170
Newport Sewage Treatment Plant	831.0	58

Table 2. Major Wastewater Contributors to Minnesota/Mississippi Rivers Upstream of Pool Three of the Mississippi River (Continued)

Wastewater Contributor	River Mile	Discharge Rate M Gal/Day
MISSISSIPPI RIVER (continued)		
Inver Grove Sewage Treatment Plant	830.3	20
Northwestern Refining Company	830.0	1,440
St. Paul Park Sewage Treatment Plant	829.0	350
J. L. Shiely Company--Larson Plant	826.5	1,440
J. L. Shiely Company--Nelson Plant	825.0	8,640
General Dynamics-Liquid Carbonic Division	824.2	698
St. Paul Ammonia Products Company	824.2	655
Great Northern Oil Company	824.0	3,230
Northwest Cooperative Mills	823.8	46
Cottage Grove Sewage Treatment Plant	819.6	425
Minnesota Mining and Manufacturing Company	817.2	5,760
Hudson Manufacturing Company	814.2	0.6
Hastings Sewage Treatment Plant	813.8	800
Prescott Sewage Treatment Plant	809.8	135

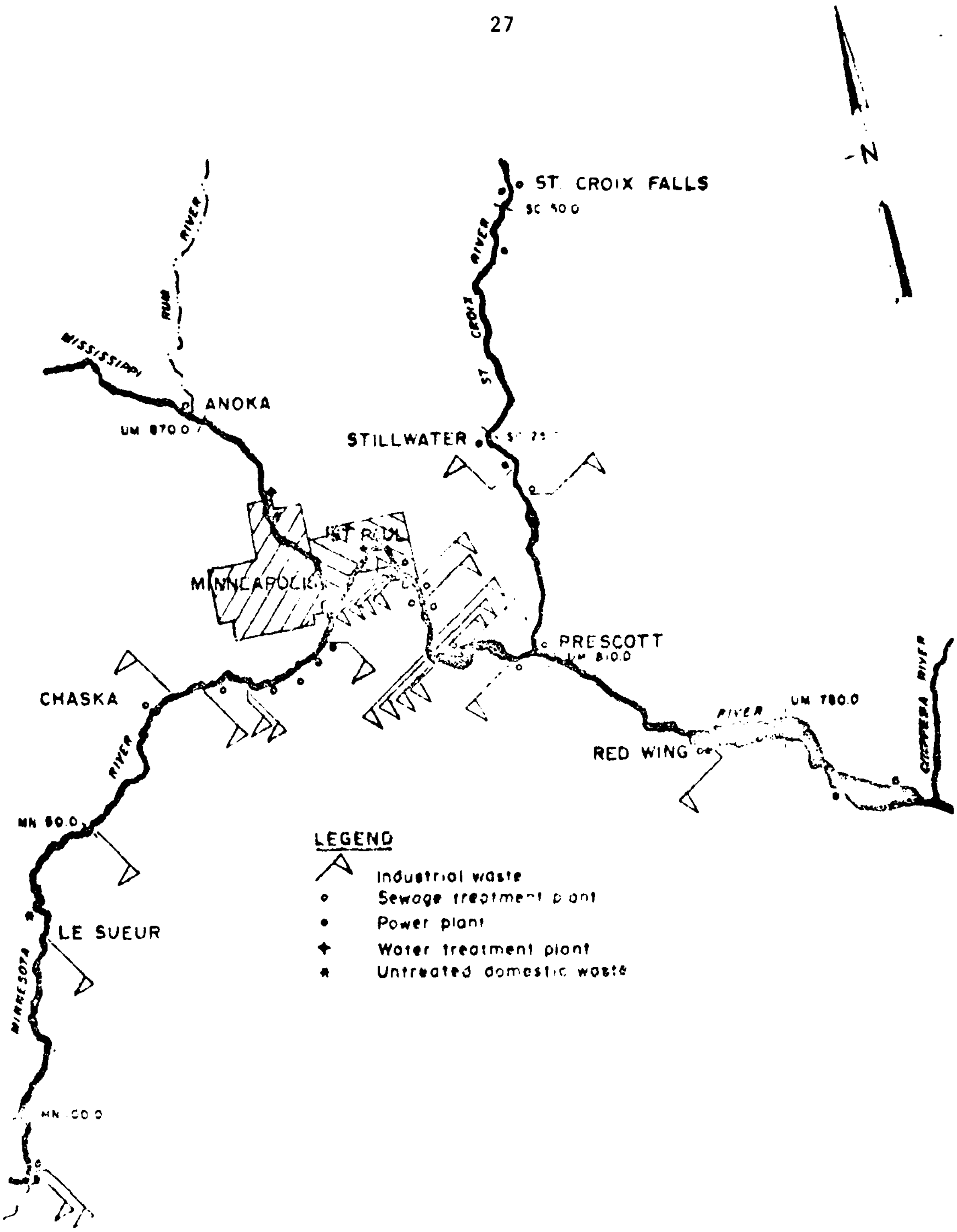


Figure 6. Locations of major wastewater contributors upstream of Pool Three, Mississippi River. (adapted from FWPCA, 1966).

The "trouble-spots" generally coincide with locations of natural drainage coulees on the Wisconsin side of the Mississippi River.

A partial description of the major existing public-use facilities which were either constructed or are aided and/or maintained by the Corps of Engineers, appears in Table 4, with a more extensive description of these facilities appearing later as Table 34.

Table 3. Locations of Pool 3 Public-Use Facilities

Location	River Mile	Bank
Prescott Island	811.7	
North Lake Access	804.5	MN
Sturgeon Lake Access	799.0	MN
Commissory Point camp & picnic	797.4	MN
Hastings small boat harbor	813.3	MN
Prescott Landing (public)	811.2	WS
Gores-Vermillion River Access	808.0	MN
Diamond Bluff Landing (public)	800.1	WS

Table 4. Records of Dredge Thompson for Pool #3, 1937 to 1971

MILE	Shore Left	Shore Right	MILE	Shore Left	Shore Right
797.0			801.1		
1			2		
2			3		
3			4		
4			5		
797.5			6		
6		176646	7		56558
7			8		
8			9		
9			802.0	46658	91500
798.0			1		
1			2		
2			3		
3			4		
4			5	86591	86590
798.5			6		
6			7		98281
7			8		
8			9		
9			803.0		
799.0		67737	1		
1		32991	2	54638	
2			3		25244
3	52539	52538	4		
4			5		
5	73963	73963	6		
799.6			7		
7		41314	8		
8		86000	9		
9			804.0		
800.0		98150	1		
1			2		
2			3		
3			4		
4			5		
5			6		
6	35133	35133	7		
7			8	53229	
8	60413		9		
9			805.0	49275	
801.0					

(continued)

Table 4. Records of Dredge Thompson for Pool #3, 1937 to 1971 (Continued)

MILE	Shore Left	Shore Right	MILE	Shore Left	Shore Right
805.1	18043		809.0		38367
2	64213		1		
3	36000		2		
4	22029		3		50009
5		27300	4		
6		67345	5		
7			6		
8			7		
9			8	214862	
806.0		36501	9		
1			810.0	72569	
2			1		
3			2		
4			3		
5			4		
6			5		
7			6		
8			7		
9			8		
807.0			9		
1			811.0	49281	49280
2			1		
3		134467	2		
4		44950	3	20769	20768
5		88178	4		
6			5		22142
7			6		50898
8			7		
9			8		39237
808.0			9		99476
1			812.0		37786
2			1		
3	15455		2		
4			3		
5	81016		4		
6	45405		5		
7	32857		6		
8			7		
9			8		

(continued)

Table 4. Records of Dredge Thompson for Pool #3, 1937 to 1971 (Continued)

MILE	Shore Left	Shore Right	MILE	Shore Left	Shore Right
813.0					
1	99759				
2	44876				
3	489986				
4					
5					
6					
7					
8					
9					
814.0					
1					
2					
3					
4	71894				
5					
6					
7					
8					
9					
815.0	93501				
1					
2					
3					
4					
5					
6					
7					
8					
9				end of pool	

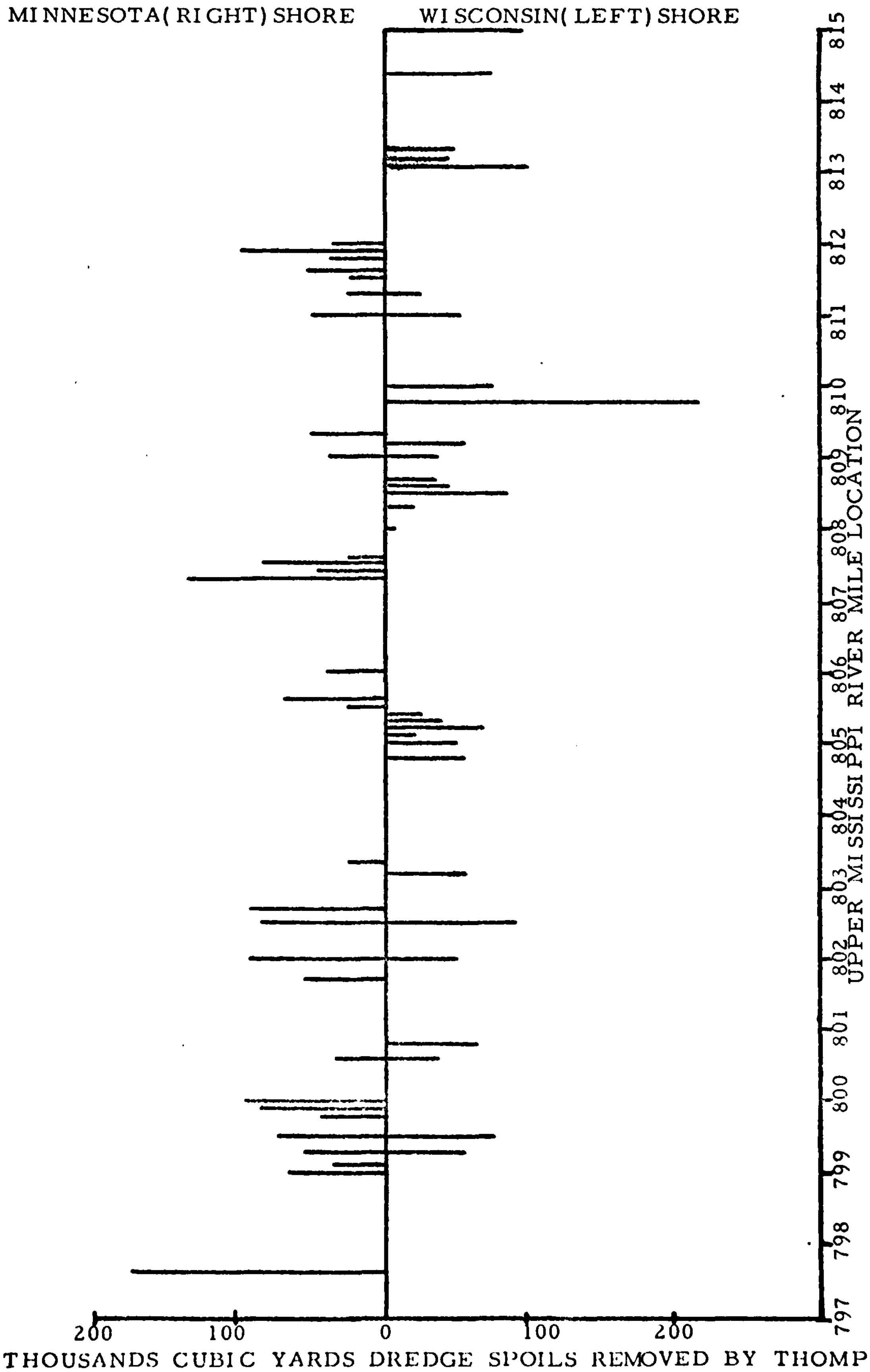


Figure 7. Records of dredge spoil removal by Dredge Thompson during period 1938 through 1971 (Pool #3)

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2. ENVIRONMENTAL SETTING

INTRODUCTION

The environmental setting of the project covered in this section is divided into (1) the Natural Setting and (2) the Socioeconomic Setting and includes a description of the study area from prior to the authorization of the nine-foot channel (1930), up to the present time. Actual construction on Lock and Dam #3 was completed in 1938. Thus, the project under consideration was initiated about 40 years ago. It is difficult to reconstruct accurately the natural and socioeconomic setting which existed prior to lock and dam construction. There are three reasons for this difficulty:

1. lack of precise data on the environmental setting prior to 1930;
2. the difficulty in isolating some changes in the river environment due to the nine-foot channel from those caused by the earlier 4-1/2 and 6-foot channels or by increased population and industrialization along the river; and
3. the practical emphasis on reducing the environmental impact of operating and maintaining the nine-foot channel assuming its continuation - not eliminating it entirely.

Therefore, the descriptions of the pre-project environmental settings in this section were reconstructed from available published information

and are of necessity brief and not complete.

In the discussion of the environmental impact of the project later in Section 3, an attempt has been made to identify changes in the study area occurring in the past four decades that are attributable to the nine-foot channel project.

NATURAL SETTING

Pool #3 accepts major contributions of waters from two sources, the Minnesota-Mississippi River with a watershed of 36,990 miles^2; and the Namekagon-St. Croix River with a watershed of 7,650 miles^2. The combined watershed of the Mississippi River/St. Croix River is about 44,800 square miles at Prescott, Wisconsin (USGS, 1964). The watersheds are illustrated in Figure 8 (UMRCBS, 1970). Some of the water flow characteristics are illustrated in Table 5, and Figure 8.

Table 5. Water Flow Characteristics for Plan Area 1

Water Flow Characteristics for Plan Area 1

SURFACE WATER		Annual Runoff Volume (million acre feet)				Flow Duration Characteristics							
							Percent of Time Flow Exists or is Exceeded						
Station	Drainage Area (square miles)	Min	Avg	Max	Units	Record Peak	1	Avg	Median 50	80	95	99	Record Low
1. Mississippi River					cfs/sq mi	4.76	1.65	0.33	0.22	0.12	0.069	0.047	0.0307
near Anoka, Minn	19,100	1.11	4.52	10.33	cfs	91,000	31,500	6,290	4,200	2,290	1,320	900	586
2. St. Croix River					cfs/sq mi	7.18	4.05	0.68	0.44	0.36	0.207	0.126	0.0098
at Mouth	7,650	1.26	2.96	5.74	cfs	54,900	31,000	5,200	3,370	2,750	1,585	965	75
3. Mississippi River					cfs/sq mi	4.65	1.3	0.27	0.17		0.05	0.333	0.0172
at St. Paul	35,800[a]	1.33	7.12	19.45	cfs	171,000	47,600	[illegible]	6,2[illegible]0		1,840	1,210	632
Total Plan Area 1	29,100		8.5		cfs/sq mi				0.28	0.188	0.107	0.0[illegible]9	0.0255
(estimated)					cfs				8,150	5,470	3,114	2,300	742
					mgd				5,2[illegible]0	[illegible]	2,012	1,490	479

GROUND WATER	Units	Existing Use	Minimum Additional Yield	Total Potential Yield
1. Sand and Gravel Aquifers	mgd		2,900	
2. Bedrock Aquifers	mgd		100	
Total Plan Area 1 (estimated)	mgd	230	3,000	3,230

[a] Includes Minnesota River.

Table 6. Mississippi River Flow at Prescott, Wisconsin, 1940-1965

Month	Median Discharge (cfs)
January	7,580
February	7,200
March	10,600
April	36,000
May	25,750
June	24,000
July	14,750
August	11,240
September	11,000
October	10,120
November	9,500
December	8,000

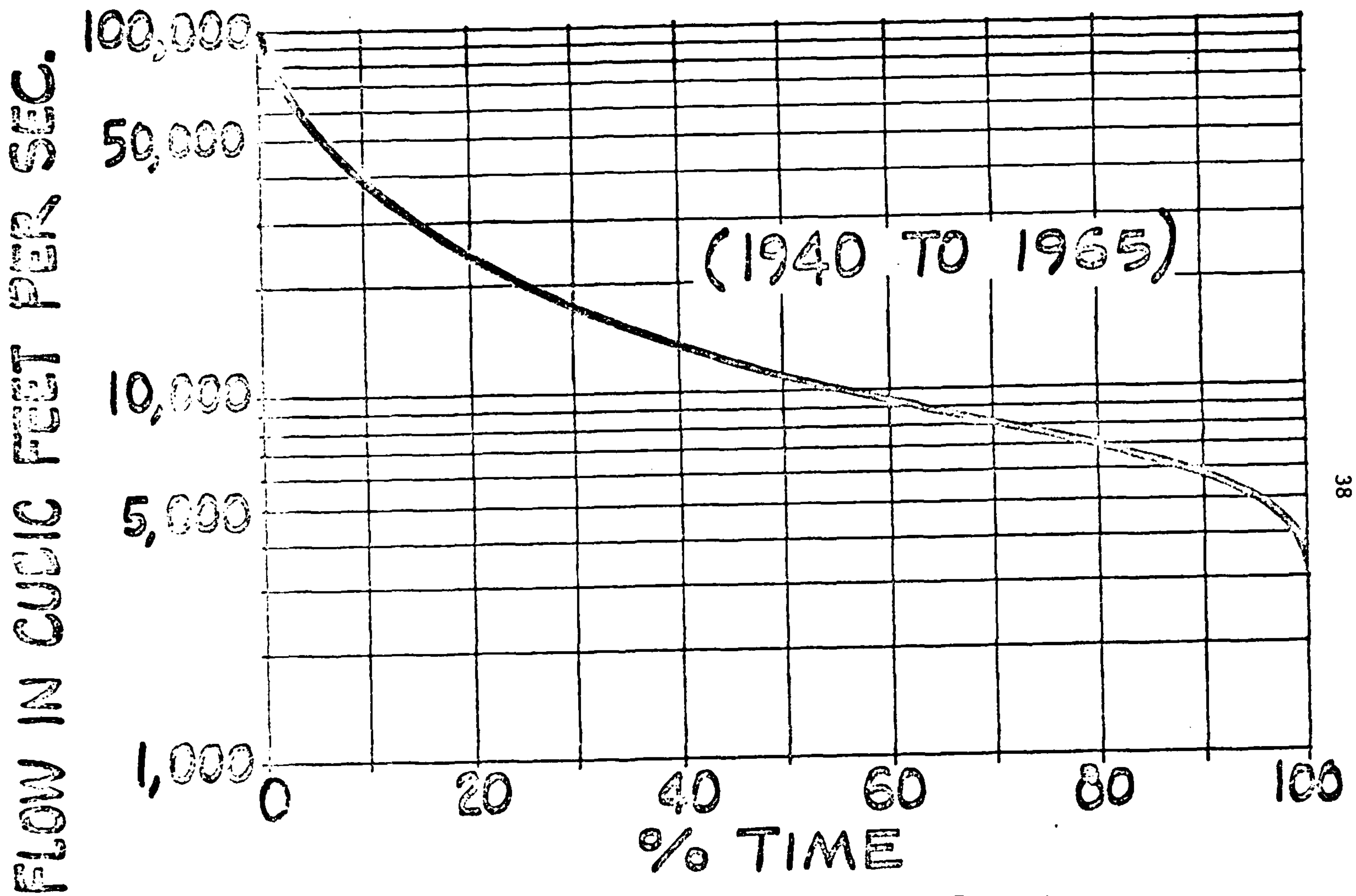


Figure 8. Flow Duration for the Mississippi River at Prescott (modified from NSP, 1973).

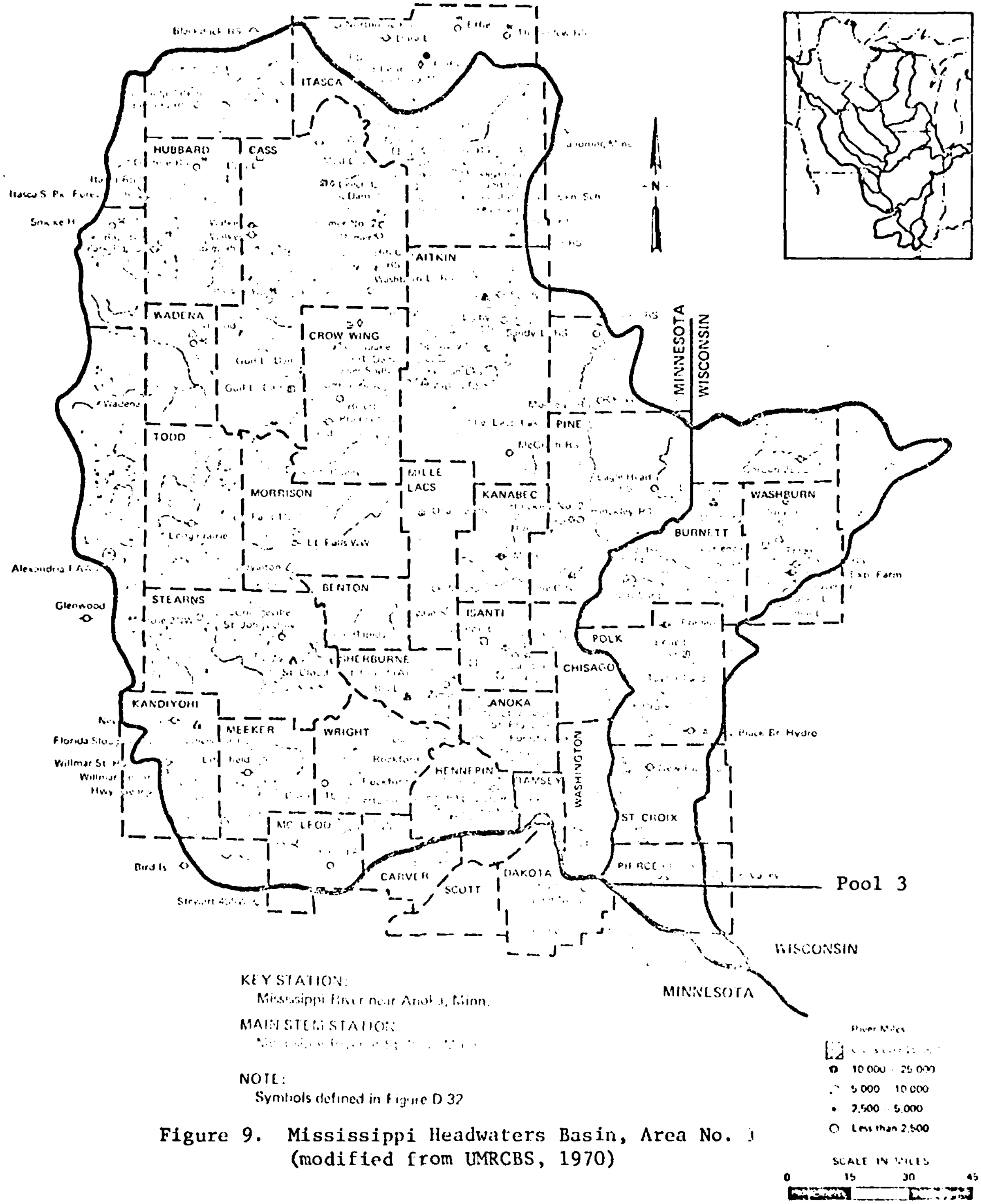
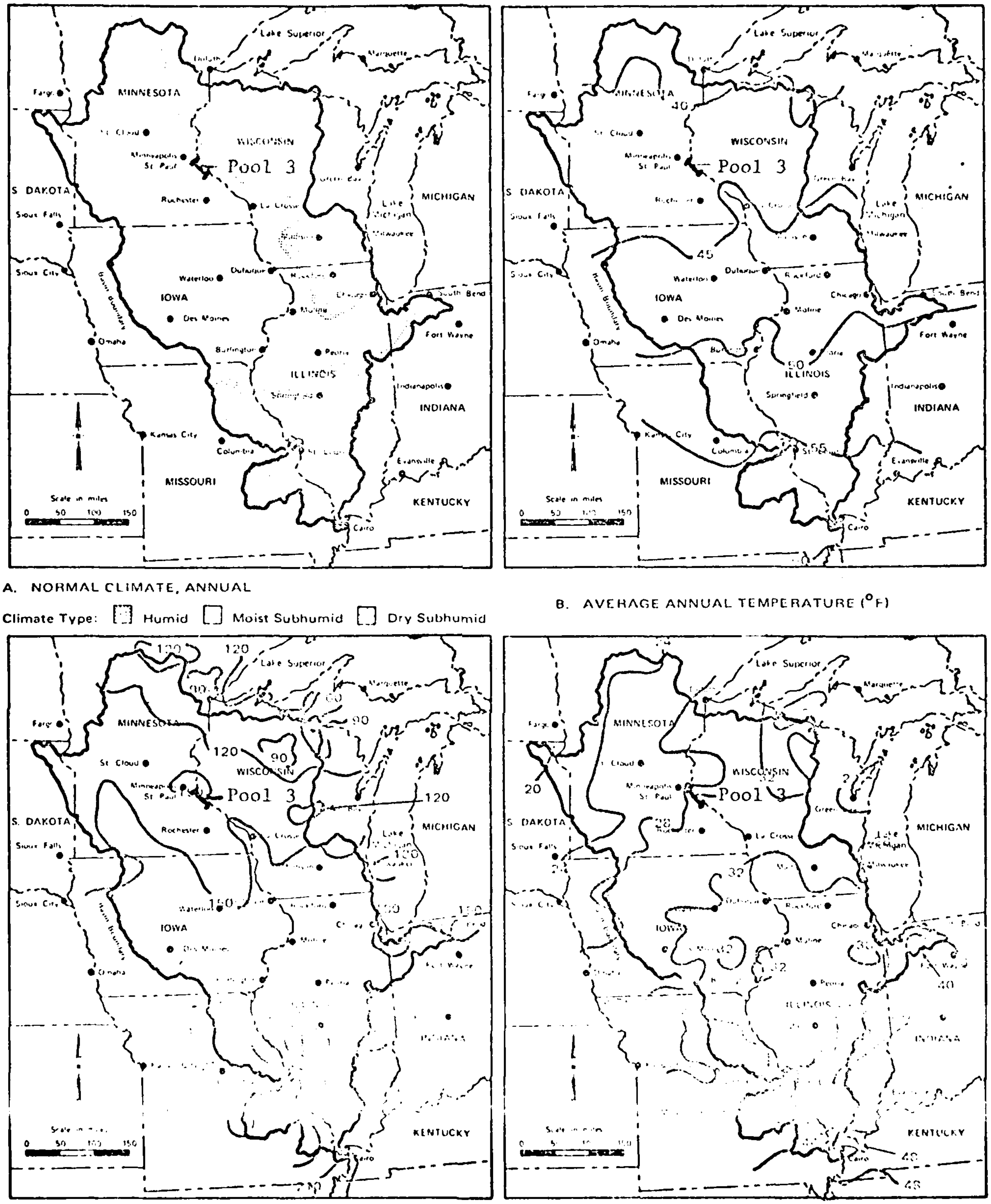


Figure 9. Mississippi Headwaters Basin, Area No. 1
(modified from UMRCBS, 1970)



A. NORMAL CLIMATE, ANNUAL

Climate Type: Humid Moist Subhumid Dry Subhumid

B. AVERAGE ANNUAL TEMPERATURE (°F)

C. MEAN LENGTH OF FREEZE-FREE PERIOD (DAYS) BETWEEN LAST 32° F TEMPERATURE IN SPRING AND FIRST 32° F TEMPERATURE IN AUTUMN

D. NORMAL ANNUAL TOTAL PRECIPITATION (INCHES)

Figure 10. Climatic data--Upper Mississippi River Basin (modified from UMRCBS, 1970)

A. MEAN ANNUAL TOTAL SNOWFALL (INCHES)

B. AVERAGE RELATIVE HUMIDITY LOCAL NOON, JULY (PERCENT)

C. AVERAGE ANNUAL POTENTIAL EVAPOTRANSPIRATION (INCHES)

(From Thornthwaite, C. W., Physical Basis of Water Supply and its Principal Uses)

D. RELATIONSHIP OF AVERAGE ANNUAL POTENTIAL EVAPOTRANSPIRATION (INCHES) TO AVERAGE ANNUAL PRECIPITATION (INCHES)

21 Evapotranspiration

48 Precipitation

Figure 11. Climatic data--Upper Mississippi River Basin (modified from UMRCBS, 1970)

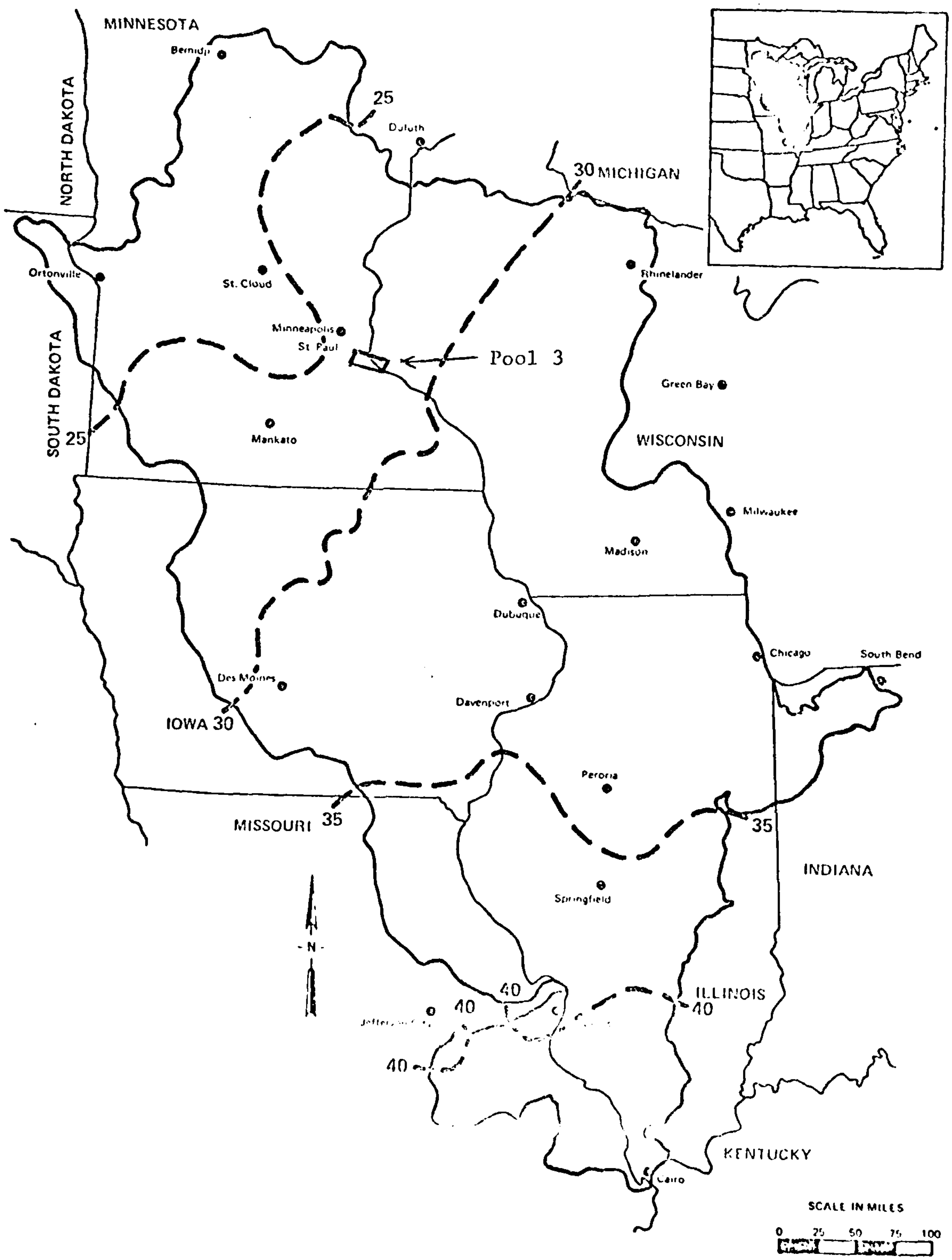


Figure 12. Average annual precipitation (inches)

Source: "Soils of the North Central Region of the United States," North Central Regional Publication No. 76, Bulletin 544, June 1960, p. 14.

(modified from UMRCBS, 1970)

The topography in and near Pool #3 derives its structure from early Pleistocene Glaciers, modifications due to water and wind erosion, and of course, activities of man in the last 200 years. The parent materials which are common in the watershed and pool areas are depicted in Figure 13, 14 and 15 and Table 7. The underlying Geological formations are described in Figures 16, 17 and Table 8. Figure 17 has a cross-section which is more closely depicted in Figure 16.

The ecosystem of Pool #3 is divided into two river systems (St. Croix, and Mississippi), but, as previously stated, only the Mississippi portion is being considered in this paper. Though the Mississippi is continuous from L/D #2 to L/D #3, there is a difference in the water quality from the portion upstream of the juncture of the St. Croix, and the remainder of the downstream pool. This requires that the upper pool and lower pool (divided by the St. Croix) be discussed separately when discussing aquatic biota. Figure 13 has shown that there is a soils transition on the Minnesota and Wisconsin sides of the Mississippi River at Pool #3. Further, there is a soils transition on the Minnesota shore as well as near the Cannon River juncture with the Mississippi, and the Vermillion River juncture with the Mississippi. Though both of these junctures are immediately downstream of L/D #3, the original pattern of flow of the Vermillion was directly under the site of the present dam structure of L/D 3. [illegible] a parallel course with the main stem of the Mississippi in the flood plain, at times entering some of its waters just downstream of the city

Table 7. Generalized Composite Geologic Column and Description of Water-Yielding Characteristics of Bedrock in the Mississippi River Basin above Prairie du Chien, Wisconsin (Adapted from UMRCBS, 1970)

Name	*Age*	*Thickness, feet*	*Description*	*Water-Yielding Characteristics*
Cretaceous aquifer:				
Undifferentiated beds	Cretaceous	0–700	Sandstone and shale, with some clay and siltstone	Yields moderate supplies of water having inferior quality
Devonian aquifer:				
Undifferentiated beds and Cedar Valley Limestone	Devonian	0–150	Limestone, dolomite, and shale	Yields moderate supplies
Maquoketa Shale, Galena Dolomite, Decorah Shale, and Platteville Limestone	Ordovician	0–375	Shale, dolomite, and limestone	Yields little water
St. Peter aquifer:				
St. Peter Sandstone	Ordovician	0–175	Sandstone; some siltstone and shale	Generally yields moderate supplies
Jordan-Prairie du Chien aquifer:				
Prairie du Chien Group	Ordovician	0–375	Dolomite, with some sandstone and shale	Yields large supplies of water in Minnesota, small supplies in Wisconsin
Jordan Sandstone	Cambrian	0–175	Sandstone; coarse grained, poorly cemented	Yields large supplies of water in Minnesota, small supplies in Wisconsin
St. Lawrence Formation	Cambrian	0–50	Dolomite, shale, and siltstone	Yields little water in Minnesota, moderate supplies in Wisconsin
Franconia-Galesville aquifer				
Franconia Sandstone	Cambrian	0–190	Sandstone with some siltstone	Yields moderate supplies of water
Galesville Sandstone	Cambrian	0–100	Sandstone	Yields moderate supplies of water
Eau Claire Sandstone	Cambrian	0–225	Sandstone with some shale	Yields little water
Mount Simon-Hinckley aquifer:				
Mount Simon Sandstone	Cambrian	0–400	Sandstone	Yields large supplies of water
Hinckley Sandstone	Precambrian	0–400	Sandstone	Yields large supplies of water
....	Precambrian	–	Sedimentary, metamorphic, and igneous rocks	Yields little or no water

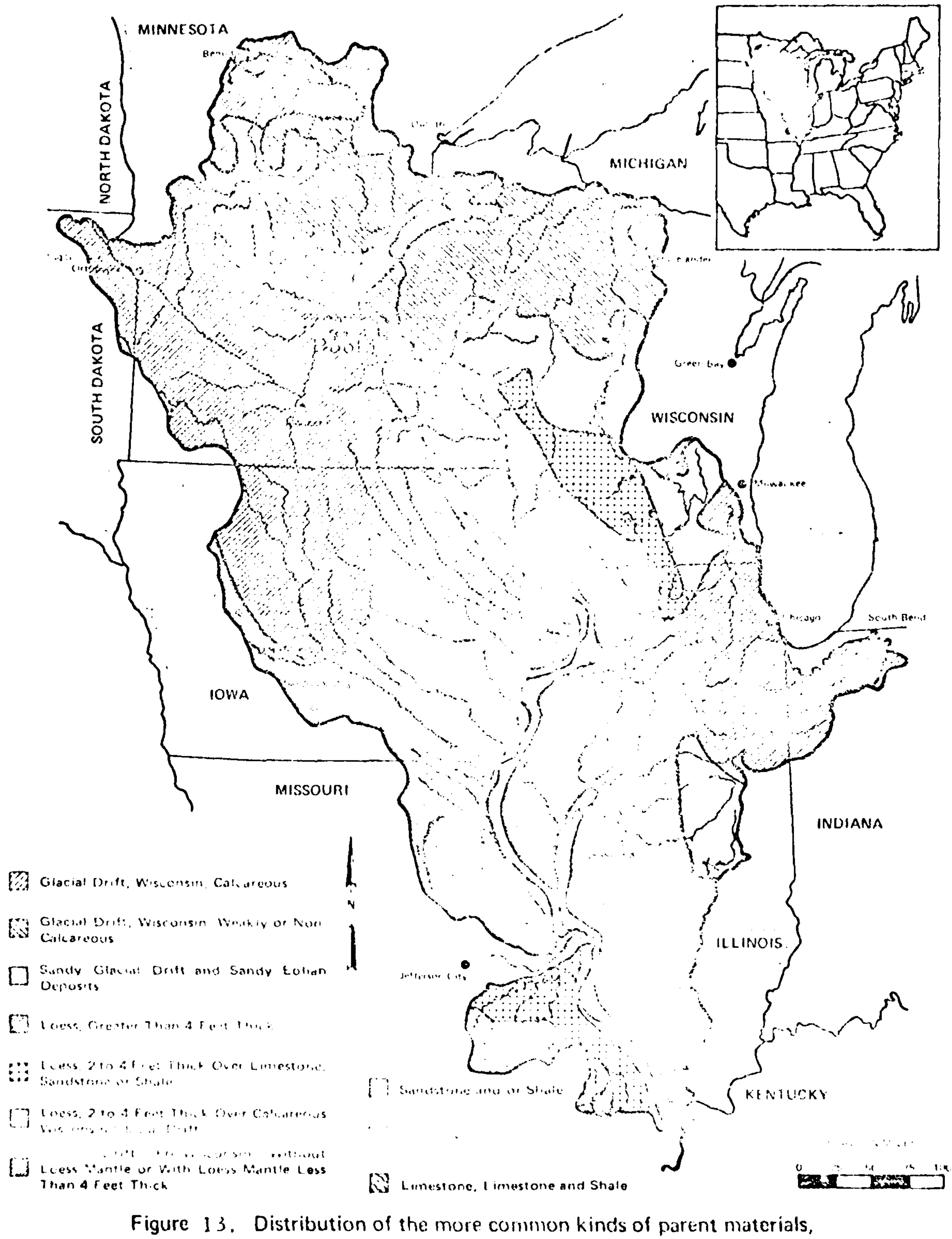


Figure 13. Distribution of the more common kinds of parent materials, Upper Mississippi River Basin.

Source "Soils of the North Central Region of the United States," North Central Region Publication No. 76, Bulletin 544 June 1960, p. 17, Agricultural Experiment Station, University of Wisconsin, Madison, Wisconsin.

(modified from UMRCBS, 1970)

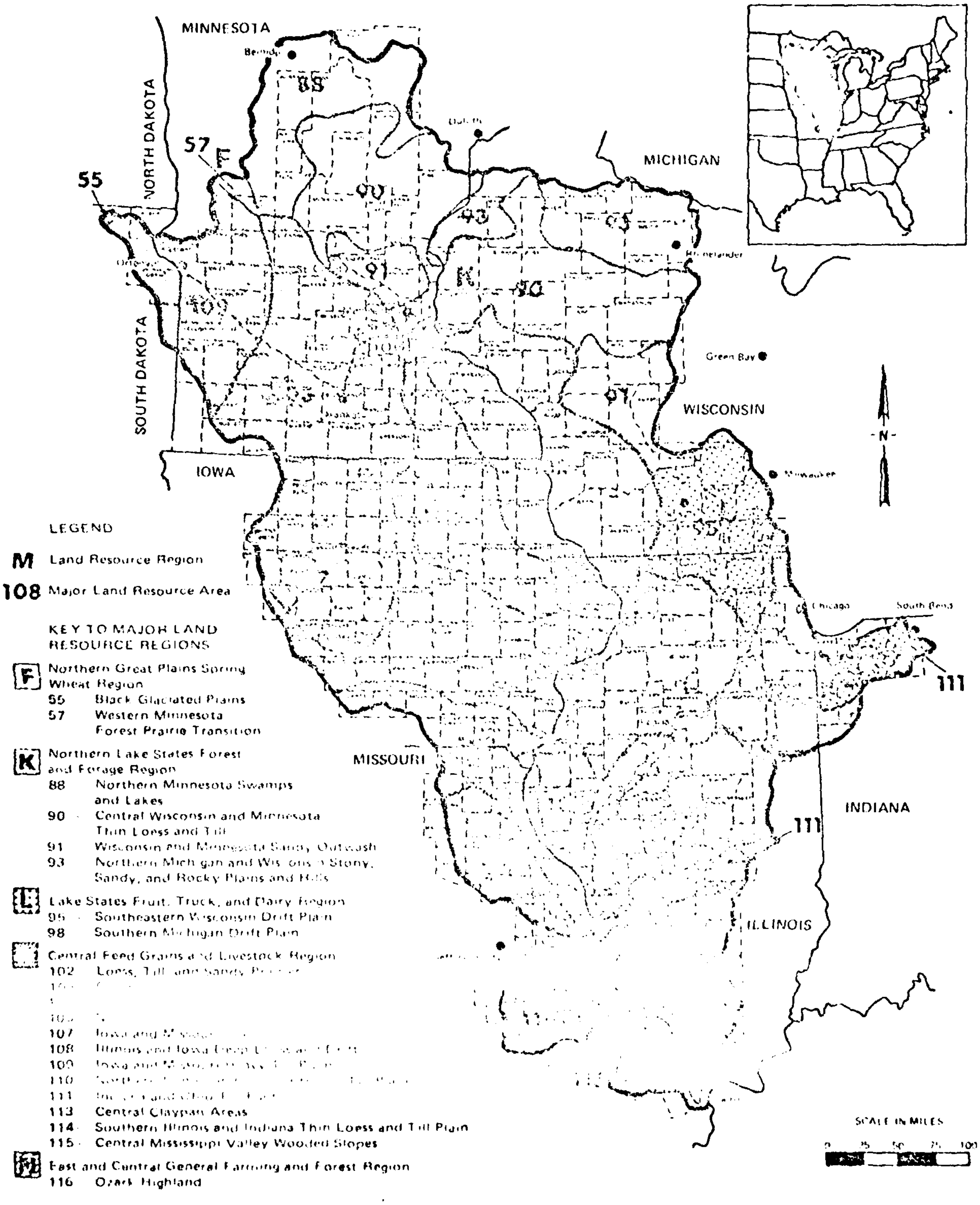


Figure 14. Land resource regions and major land resource areas, Upper Mississippi River Basin.

Source: "Land Resource Regions and Major Land Resource Areas of the United States," Agricultural Handbook 296, Soil Conservation Service, U.S.D.A., December 1965.

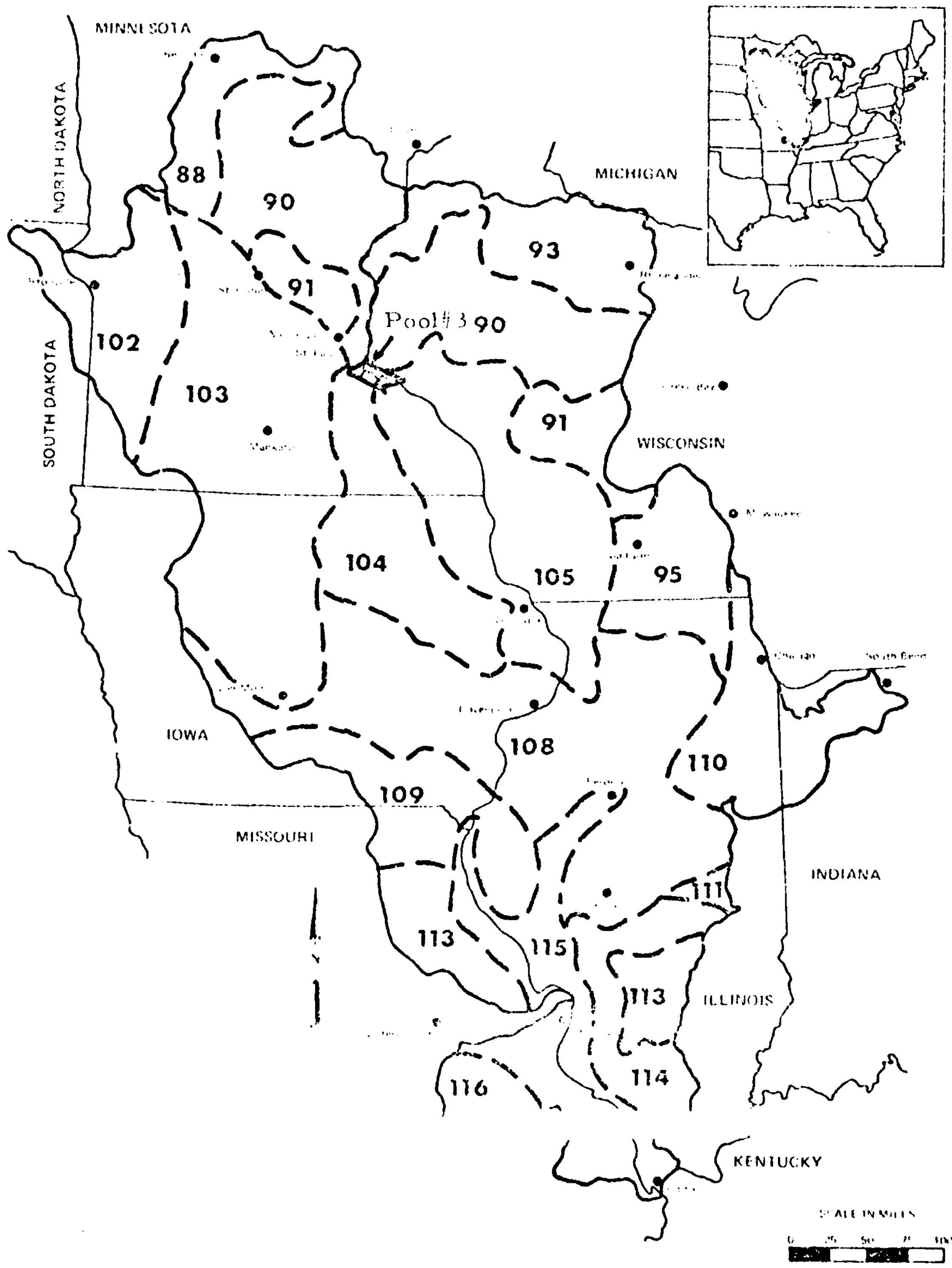
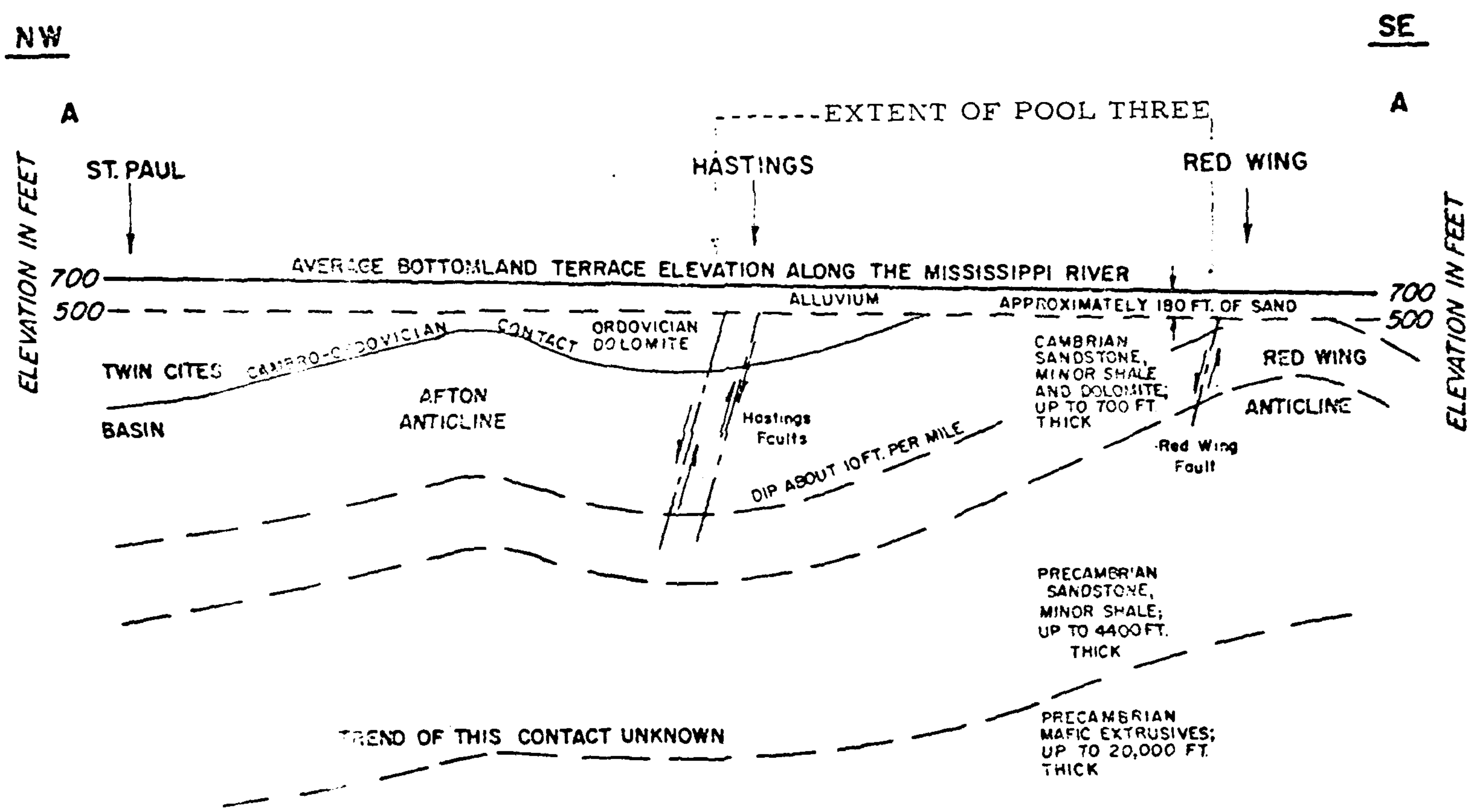


Figure 15. Land resource areas.
Source River Basin Atlas, SCS ... 1962.
(modified from UMRCBS, 1970)



HORIZONTAL SCALE: 1 IN. = APPROX. 6 MILES
VERTICAL SCALE: VARIABLE AND HIGHLY EXAGGERATED

Figure 16. **Regional Geologic Cross Section A-A**
(modified from NSP, 1973)

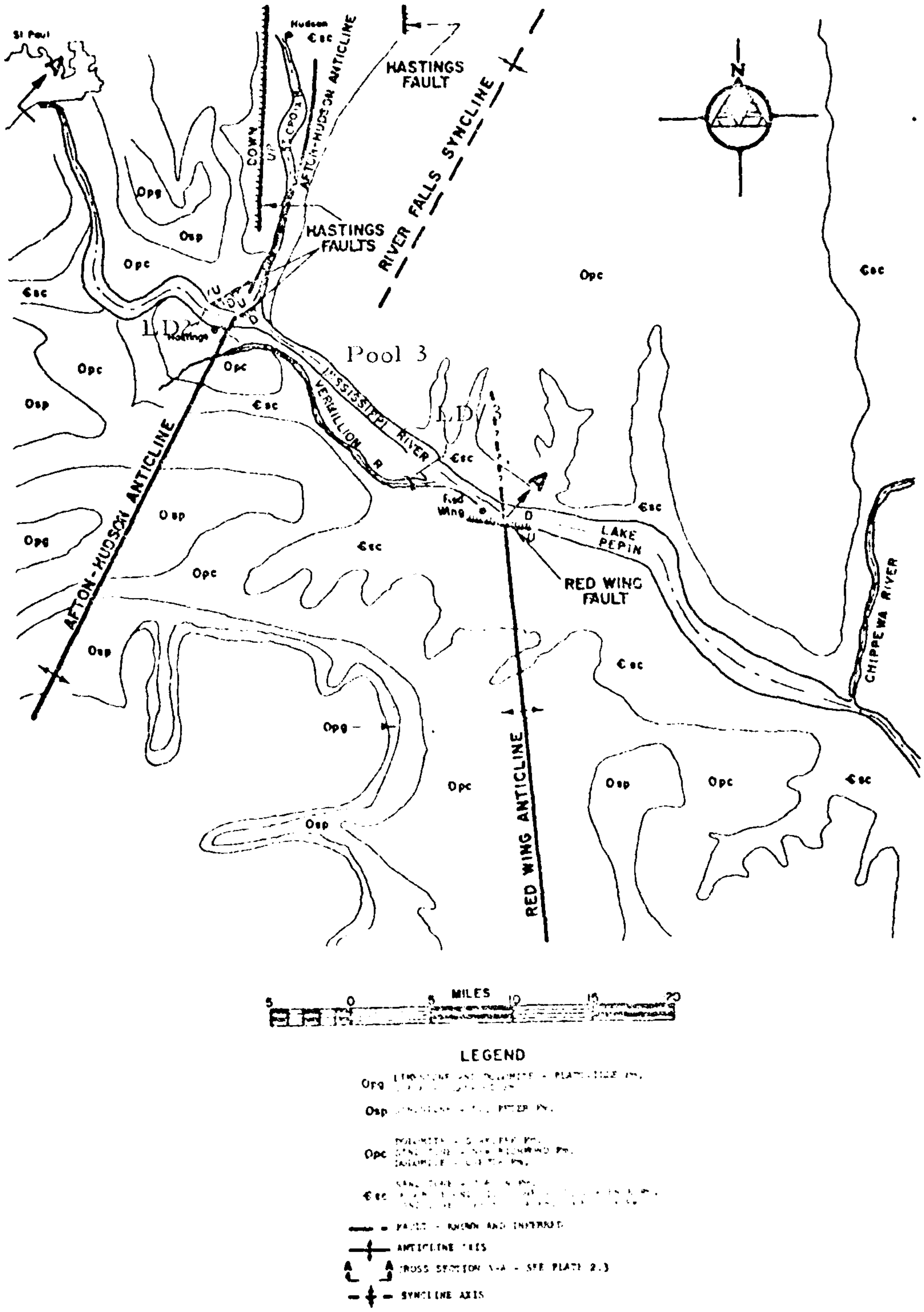


Figure 17. Regional Geologic Map of Bedrock Formations (modified from NSP, 1973)

Table 8. Geologic Formations in the General Area of the Site

GEOLOGIC AGE ERA PERIOD	GEOLOGIC NAME	APPROX. THICKNESS IN FEET	DESCRIPTION	REMARKS
Cenozoic Quarternary	Recent deposits		Unconsolidated clay, silt, sand, and gravel	Largely Mississippi and Vermillion River deposits
	Pleistocene	20 to 200	Unconsolidated clay, silt, sand, gravel and boulders deposited as till, outwash and loess	Largely from Superior and Des Moines lobes of Wisconsin glaciation
Paleozoic Ordovician	Oneota	100	Dolomite	Exposed along river bluffs
Cambrian	Jordan	100	Sandstone	An important aquifer
	Saint Lawrence formation	43	Dolomite, siltstone and silty dolomite	
	Franconia Formation (St. Croix series)	180	Sandstone and shale	Aquifer zones. Uppermost bed-rock at site
	Dresbach formation (St. Croix series)	100+	Sandstone, siltstone	Aquifer zones

Table 8. Geologic Formations in the General Area of the Site (Continued)

Precambrian Keweenawan	Hinckley formation	100+	Sandstone	An important aquifer
	Red clastic series		Sandstone and Red Shale	May not be present under the site
	Volcanics		Mafic lava flow with thin layers of tuff and breccia	May be present under the site
	Granite and associated intrusives			Principal basement rock under the site

of Hastings, Minnesota. The Vermillion has caused flooding at Hastings, (COE, 1971).

The pool can be divided in another manner, in that it can have Physical and Cummunities sections. Under Physical considerations, climatic, geologic and hydrologic elements are included, while in the Communities section, the flora and fauna of terrestrial and aquatic ecosystems are iterated. These subdivisions are artificial at best, but are so considered for organizational reasons. The interactions of of all of the elements are recognized in the need for this paper. The Pool #3 report alone is insufficient to understand the pool completely since all of the activities in any upstream section of the watersheds will have effects felt somewhere along the line in Pool #3.

Physical Aspects

Geology

At least four glaciation periods occurred in this area in the last million years, the advances and retreats leaving debris in patterns which helped determine waterways of the St. Croix River and the Mississippi. The upper pool ends at the Hastings Faults and the lower pool receives its water from the main stem of the Mississippi as well as the waters of the St. Croix which are directed along the Afton-Hudson Anticline (Figure 17). The bluffs along either side of the river downstream of the St. Croix juncture range in height from 200 to 390 feet over the flat pool of 675 feet. The bluffs are Shakopee Dolomite overlying New Richmond Sandstone overlying Oneota Dolomite on the

middle portion of the pool on the Wisconsin side; while on the Minnesota side, and on the lower side of the Wisconsin shore, the bluffs are of Jordan Sandstone overlying St. Lawrence Dolomite overlying Franconia and Dresbach formations of Sandstone. The interconnection of the St. Croix River and main stem Mississippi, less than 5 miles downstream from the Minnesota River/Mississippi River confluence, creates a very mixed geologic formation and an interface of several soils types at Pool #3. (See Figures 13-17 and Tables 7 and 8).

The very soft sediments left by the glacial-river Warren are being washed into the Mississippi River by the Minnesota River which now occupies the valley. These sediments ranged from 80' to 180' deep and form a very great portion of the sediment load carried by the Mississippi River in Pool #3.

<u>Climate</u>

The climate in the upper Mississippi River Valley varies from dry and sub-humid in the western part of Minnesota, to humid near Lake Superior. The air temperatures, extreme winds and rainfall are illustrated in Figure 18. An exception might be noted in maximum rainfall, in that a storm on July 21-22, 1972, recorded a 13" rainfall which resulted in severe flooding losses in excess of $20,000,000 along a line from Otter Tail/Douglas County border to Duluth. Figures 18 and 19 further delineate the snowfall, humidity, etc., of this region.

Soils

The soils in the Pool #3 area are primarily pedalfer andvary from sandy clay loams to loamy sands. On the bluff tops, the soils vary in thickness and quality, generally being medium to coarse sandy.

In the flood-plain, the soils are organic river-bottom types to sandy, being inundated periodically and generally poorly drained. The very fine silt-load of the Mississippi tends to clog the soils fro drainage, leaving many untillable "pot-holes".

Figures 13-15 illustrate the geographical distribution of the various soils types, while Figure 19 shows the erosion potential of these soils.

Groundwater

There are large quantities of groundwater in the headwaters of the watershed, with decreasing amounts of iron content progressing from North to South. The distribution of productive aquifers is presented in Figure 20. The aquifers supply about 95% of the water supply outside the Minneapolis/St. Paul Metropolitan area. Analysis of groundwater within the Pool #3 area is presented as Table 9. Figure 21 shows the groundwater in the Jordan-Prairie Du Chien aquifer in the vicinity of Pool #3.

In the Twin Cities area and thirteen surrounding communities, the Mississippi River supplies the potable water. There are numerous in-

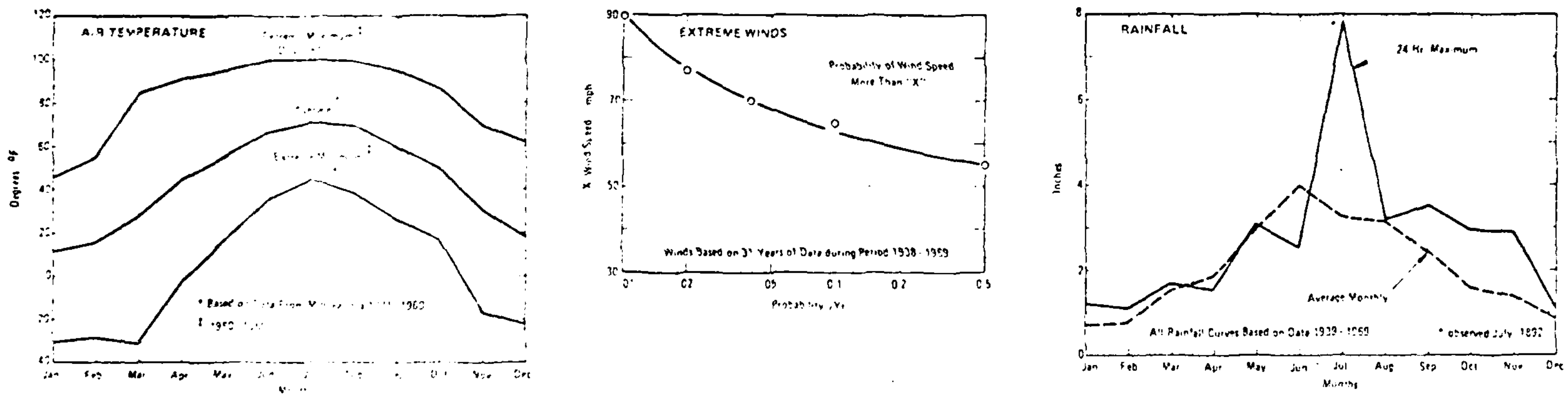


Figure 18. Climate of the Region

dustrial wells, primarily tapping the Jordan Sandstone aquifer, presently using about one-fourth of the potential. An analysis of the Mississippi River is presented as Tables 9 and 10.

<u>Hydrology</u>

Runoff in the upper Mississippi River watersheds vary from one to eight inches per year with four inches being the average in the Pool #3 area.

The ten largest floods of record, have been recorded at Prescott, Wisconsin on the USGS station, and at Hastings, Minnesota at the C. M. St. P. & P. Railroad Gauge.

At Hastings, the ten known floods in order of magnitude are shown in Table 11. The records date from 1873. During the 1965 flood, (greatest flood of record), the river velocities ranged up to 6.5 feet per second and rose to its crest in twelve days.

At Prescott, Wisconsin, the tne floods of record in order of magnitude are shown in Table 12.

The minimum flow of record is for July, 1940, at Prescott, Wisconsin as being 1,330 cfs.

The most serious floods in Pool #3 are associated with excessive snowmelt runoff and rainfall. Major floods occur on the average 2-3 years out of ten. The three residential communities most affected are

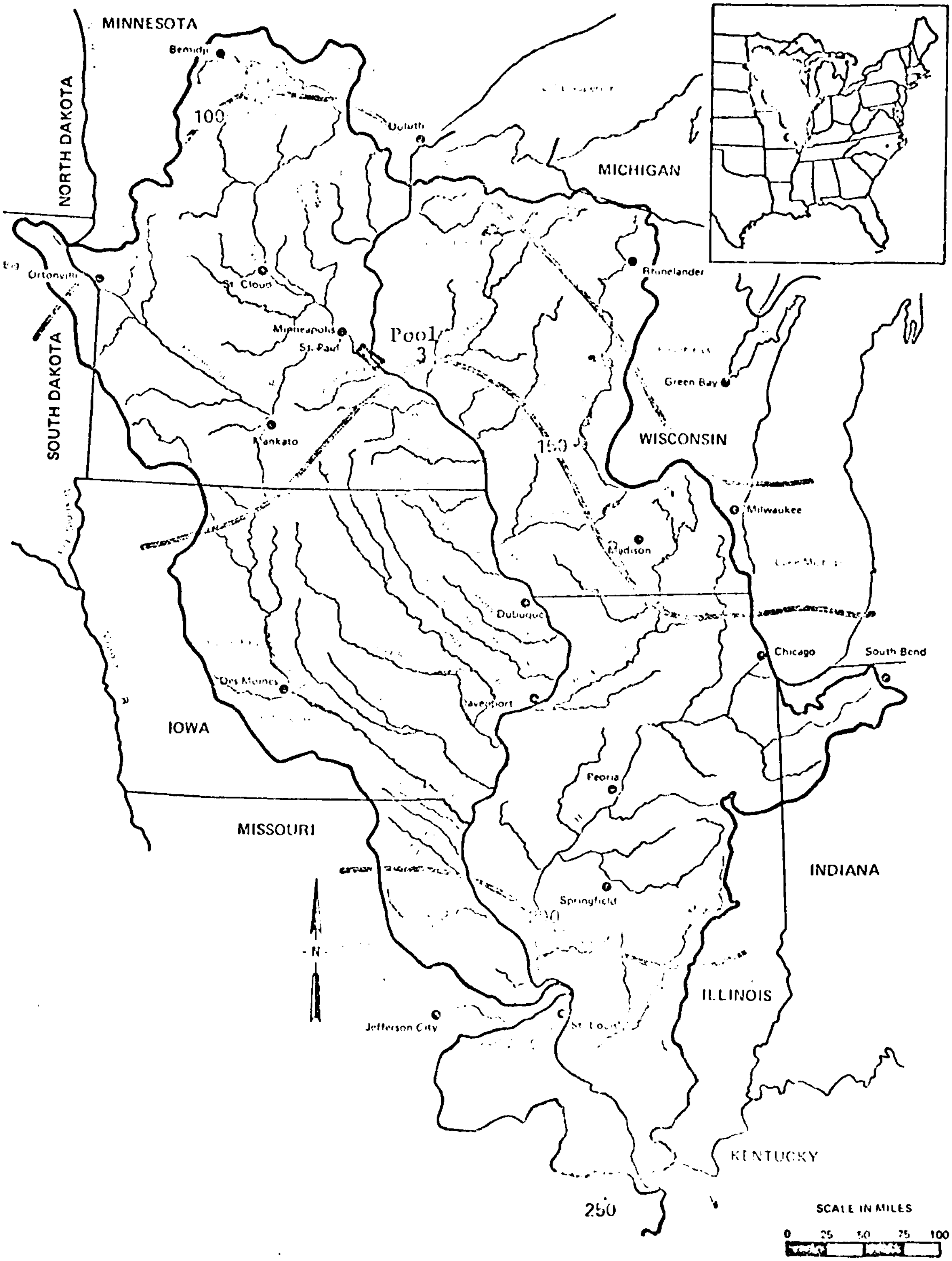


Figure 19. Rainfall erosion potential mean annual values of erosion index, Upper Mississippi River Basin

Source: W. H. Wischmeier, *Rainfall Erosion Potential*, Agricultural Engineering, vol. 43, no. 4, pp. 212–215, 225, April 1962.

(modified from UMRCBS, 1970)

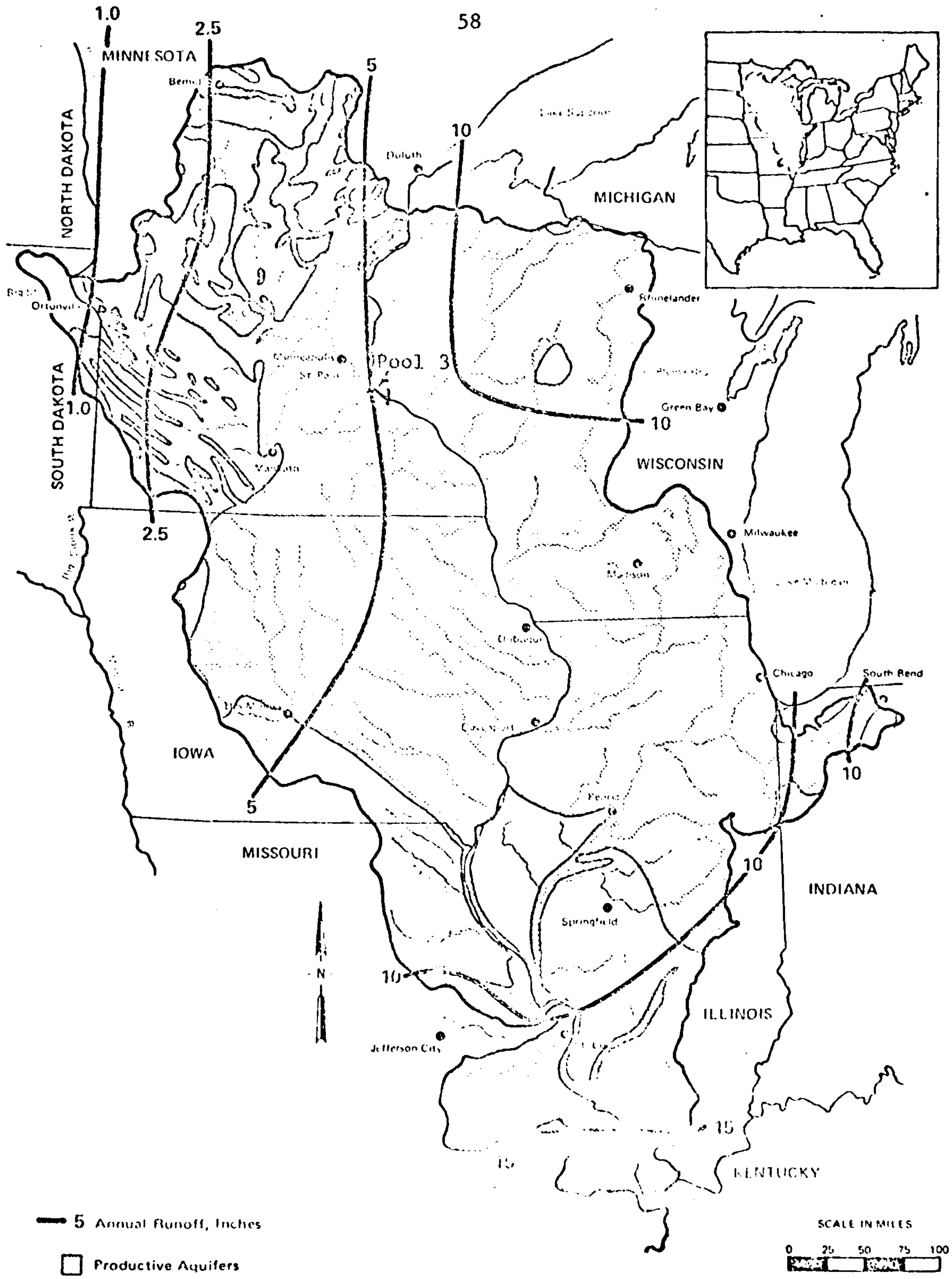


Figure 20. Average annual runoff and productive aqueifers, Upper Mississippi River Basin.
Source: U.S.G.S. Water Supply Paper 1800, Plate 1.
(modified from UMRCBS, 1970)

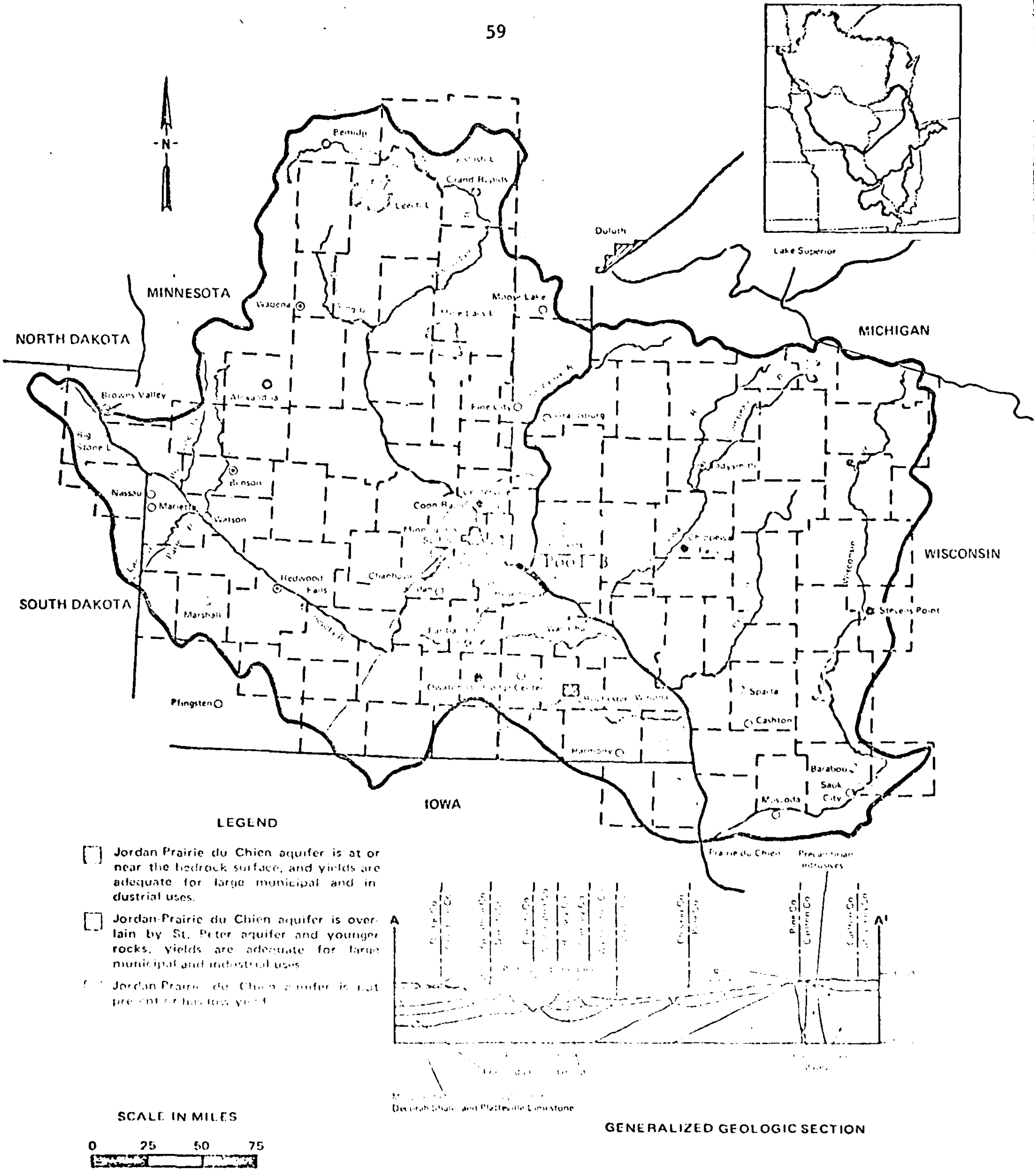


Figure 21. Ground water in the Jordan-Prairie du Chien aquifer, Mississippi River Basin above Prairie du Chien, Wisconsin (modified from UMRCBS, 1970)

Table 9. Results of Chemical Analysis of Pool #3 Groundwater, in ppm

Total dissolved solids	453
Noncarbonate hardness (as $CaCO_3$)	51
Carbonate hardness (as $CaCO_3$)	184
Total hardness (as $CaCO_3$)	235
Bicarbonate alkalinity (as $CaCO_3$)	185
Carbonate alkalinity (as $CaCO_3$)	0
Total alkalinity (as $CaCO_3$)	185
Calcium (as $CaCO_3$)	168
Magnesium (Mg)	67
Silica (SiO_2)	12.8
Iron (Fe)	0.08
Manganese (Mn)	Less than 0.01
Chlorides (Cl)	10.0
Sulphates (SO_4)	31.0

Table 10. Summary of Analyses for Mississippi River Water Samples Taken at the Pool #3

Analysis in mg/l	Minimum	Maximum	Average
Solids			
Total	209	427	286
Dissolved	167	366	254
Suspended	1.4	232	29
Hardness (as $CaCO_3$)			
Total	128	268	185
Calcium, Ca	84	180	120
Magnesium, Mg	44	88	65
Alkalinity ($CaCO_3$)			
Total	102	193	151
Phenolphthalein	0	24	3.4
Gases			
Ammonia nitrogen, N	0	1.1	0.38
Anions			
Chloride, Cl	2	32.9	12.5
Nitrate Nitrogen, N[a]	0.03	3.6	1.0
Sulfate, SO_4	10	80	38
Phosphorus (Soluble), P[a]	0.082	0.33	0.17
Silica, SiO_2	0.4	14.3	7.7
Cations			
Sodium, Na	6	28.5	12
Total Iron, Fe[a]	0.11	2.2	0.7
Total Manganese, Mn	0	0.08	0.03
Miscellaneous			
Color, APHA Units[a]	20	100	55
Turbidity, JTU	1	52	15.5
Ryznar Index at 77°F	5.9	8.5	7.2
Conductivity, mmhos	286	572	392
pH	7.4	9.2	8.0

[a]Samples from 1/8/70 to 12/16/71 only. (modified from NSP, 1973)

Hastings, Minnesota; Prescott, Wisconsin; and Point Douglas, Minnesota. The 1965 flood of record was probably the most severe since 1851. The Flow Duration for the Mississippi at Prescott, Wisconsin (mid-Pool #3) is shown in Figure 8. The average annual damages expected in Pool #3 at 1966 prices is set at $43,300 in 1966; at $67,500 in 1980; and an expected $176,700 by the year 2020 (UMRCBS, 1970).

Extensive flood-plain management has been set into action to minimize the deleterious effects of periodic flooding on flood-plain communities. The Minnesota Flood Plain Management Act is one step by the State of Minnesota, while a wide-coverage study of flood management has been carried out for Hastings, Minnesota, being completed in June, 1971, by the Corps of Engineers (COE, 1971). Concern for flood effects were extensively studied by the Harza Engineering Company for Northern States Power Company as a safety measure during the planning and implementation of the construction of the Prairie Island Nuclear Generating Plant near the Lock andDam #3 within the lower reaches of Pool #3 (NSP, 1973). Forecasts were made for worst realizable flood conditions for a 704 foot stage (normal is 675 flat pool), and a protective wall was constructed at 705 feet.

The average discharge is 15,600 cfs as measured at Prescott, Wisconsin. There are no major sources of water into Pool #3 downstream of Prescott, prior to Lock and Dam #3. The average is measured over a 42 year period. Flood flows are not materially affected by any water storage within the pool.

Table 11. Highest ten known floods in order of magnitude for Mississippi River at Hastings, Minnesota

Order Number	Date of Crest	Maximum Stage feet	Crest Elevation feet	Peak Discharge cfs
1	April 18, 1965	24.80	694.52	171,000
2	April 16, 1969	23.10	692.82	155,000
3	April 16-17, 1952	20.60	690.32	117,000
4	April 17, 1951	18.82	688.54	87,000
5	April 30, 1881	18.20	687.92	---
6	April 6, 1897	17.2	686.92	---
7	June 17, 1880	16.94	686.66	---
8	June 30, 1957	16.40	686.12	81,000
9	June 30, 1908	15.6	685.32	---
10	June 8, 1916	15.4	685.12	---

Table 12. Highest ten known floods in order of magnitude for Mississippi River at Prescott, Wisconsin.

Order Number	Date of Crest	Peak Discharge cfs
1	1965	228,000
2	1969	197,000
3	1952	155,000
4	1881	134,000
5	1951	128,000
6	1950	101,000
7	1897	
8	1880	
9	1957	94,000
10	1908	

Sediment load information is illustrated in Figures 22 and 23. As stated earlier, the main sediments are derived from the Minnesota River. The actions of commercial barge traffic is to resuspend many of these sediments during maneuvering. Farm runoff is also a major source of sediment yields. Winter sediment measurements are lowest.

Biological Aspects

Terrestrial Vegetation

The vegetation of the upper Mississippi River watersheds range from grasslands in the western portion of Minnesota, to the mixed deciduous/coniferous of Wisconsin and Eastern Minnesota, to the deciduous forests in and around Pool #3. A forest type distribution is seen in Figure 24. On the bluff tops are farming areas, generally not thought of as forested. Within the Pool #3 river valley and its feeder coulees, the lowlands are a portion of the Minnesota State Hardwood Forest, consisting of an elm/ash/cottonwood complex in the lowest areas, and an oak/maple/hickory comples as the elevations increase from the water level of the pool. Much of the original forests have been cut over in what was once a very rich forestry area.

A considerable portion of the estimated 3,430 acres of Crop lands lying above water in Pool #3 are forested. An extensive forest inventory was prepared for the Corps as a part of the Master Plan for Resource Management for Pool #3 (COE, 1967). It is in the form of overlays for the navigation charts for the pool. These overlays along with the associated booklet on the management plan should be consulted

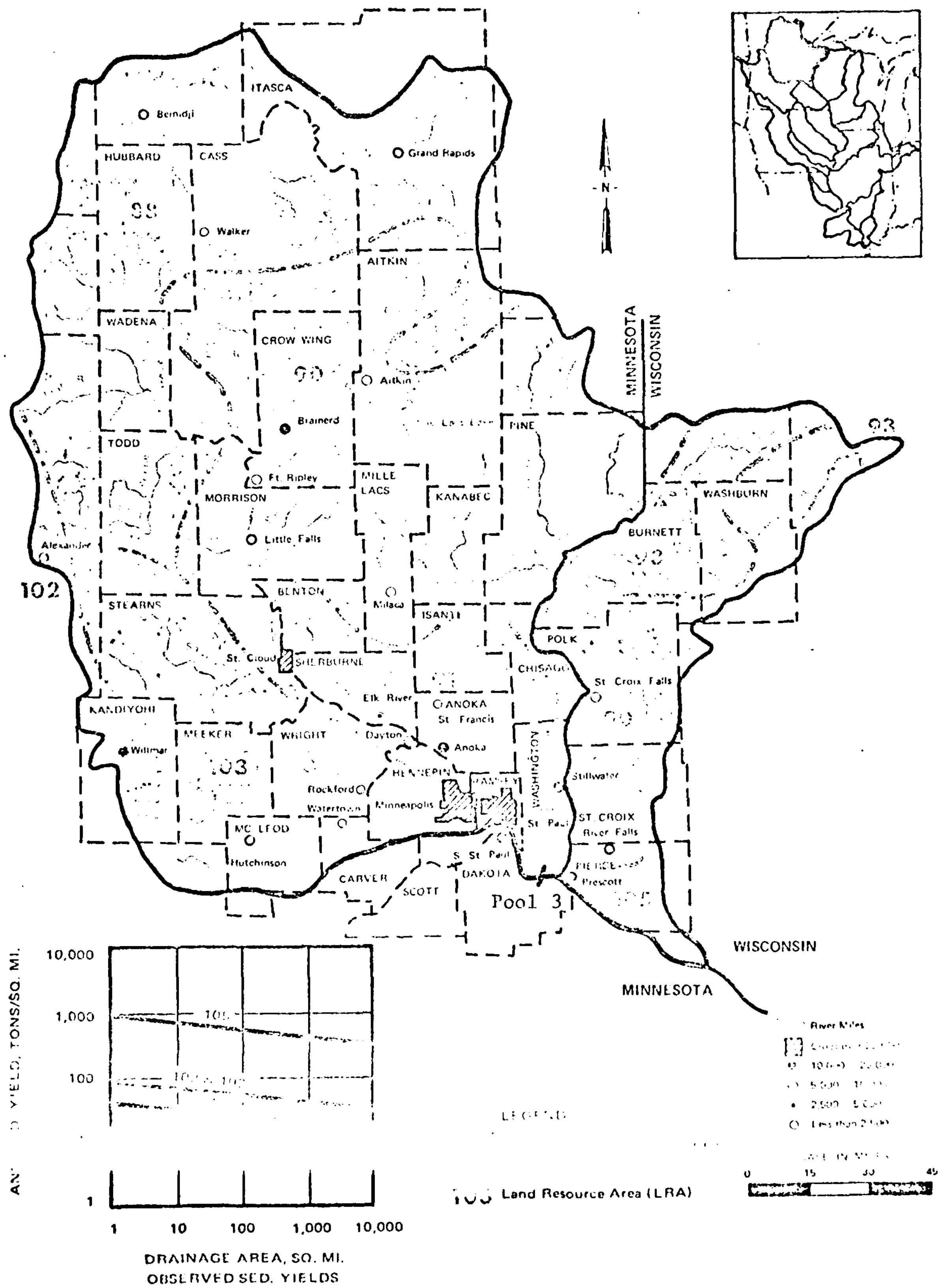


Figure 22. Mississippi River Headwater Basin, Planning Area 1
(modified from UMRCBS, 1970)

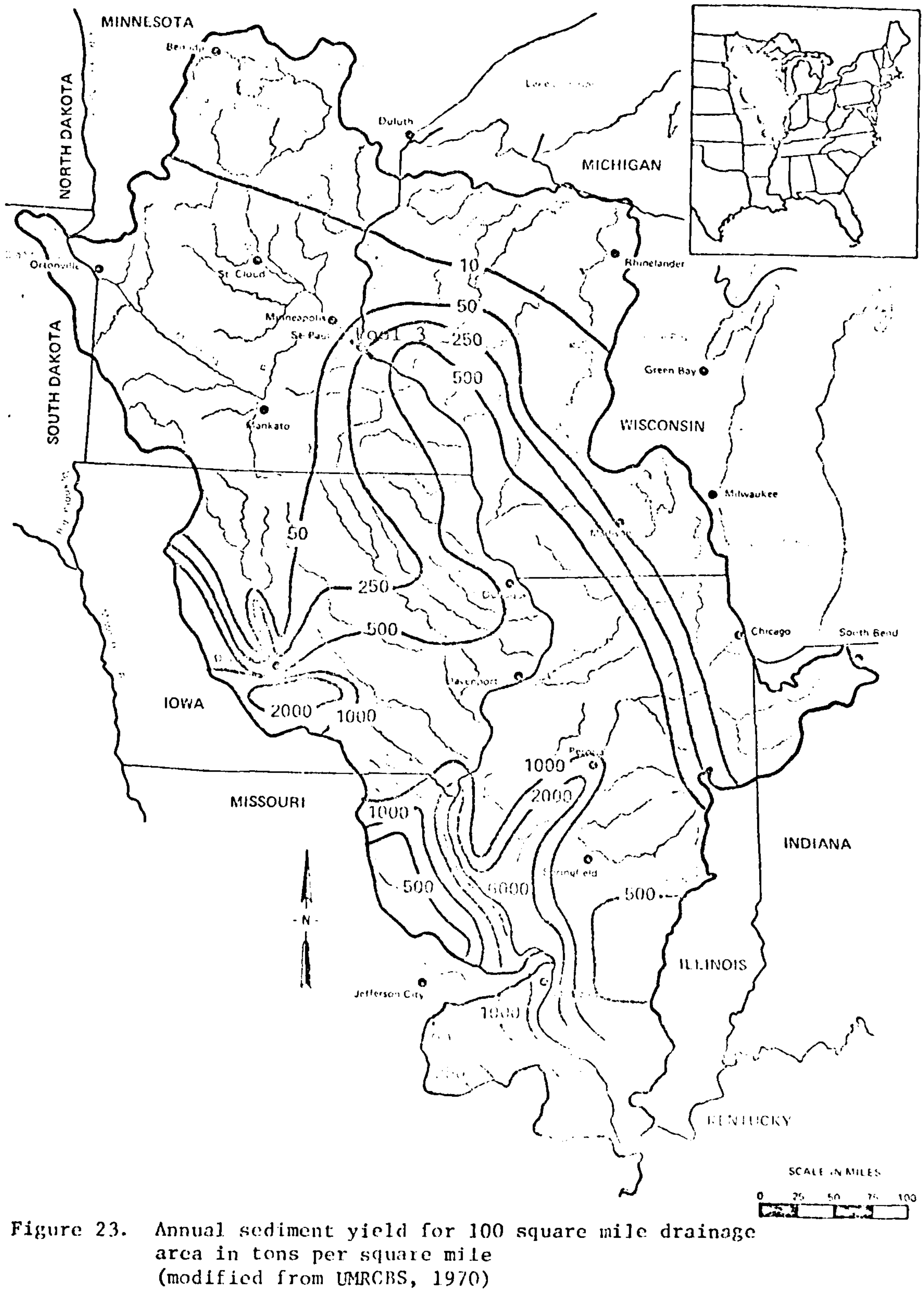


Figure 23. Annual sediment yield for 100 square mile drainage area in tons per square mile (modified from UMRCBS, 1970)

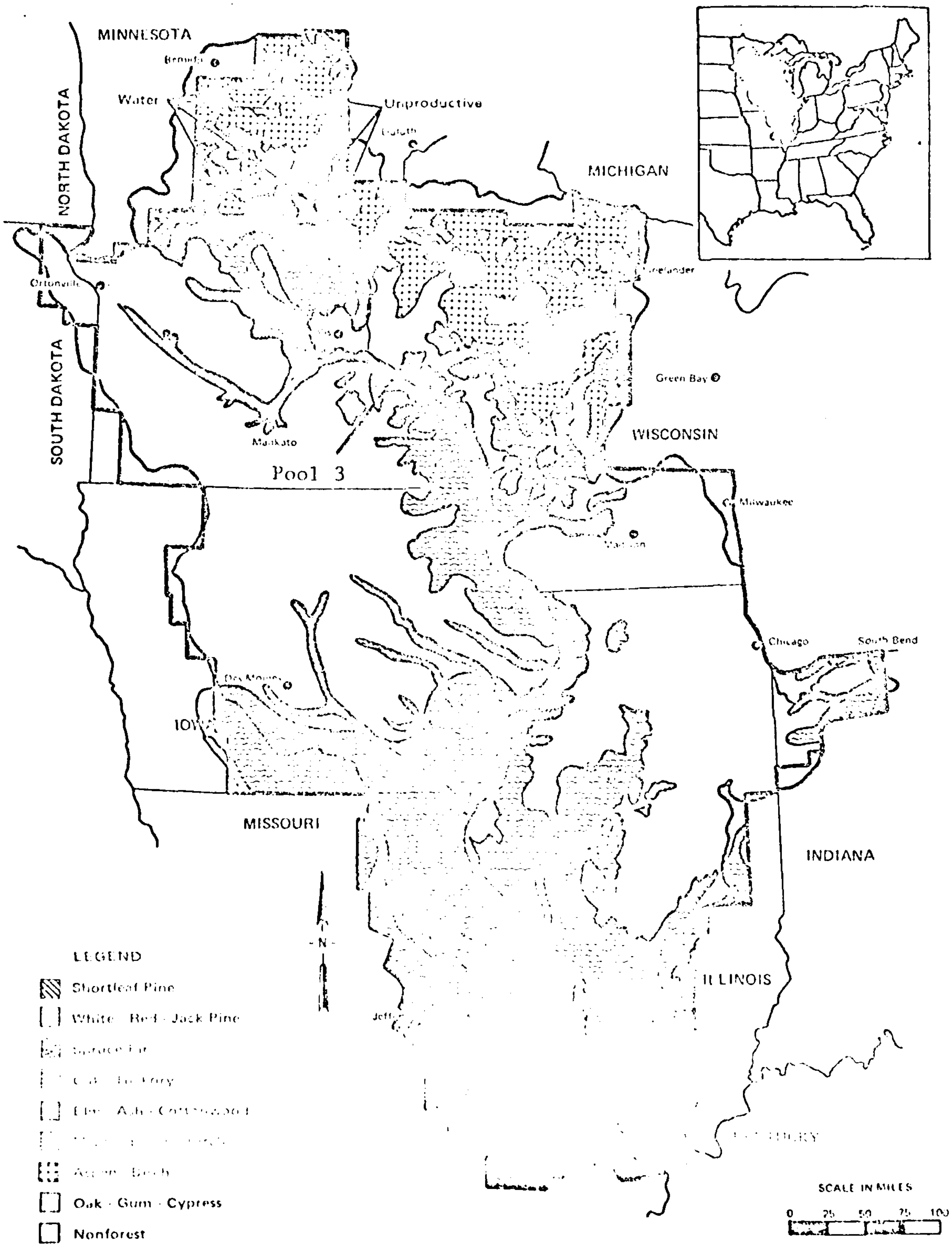


Figure 24. Major Forest Types, Upper Mississippi River Basin (modified from UMRCBS, 1970)

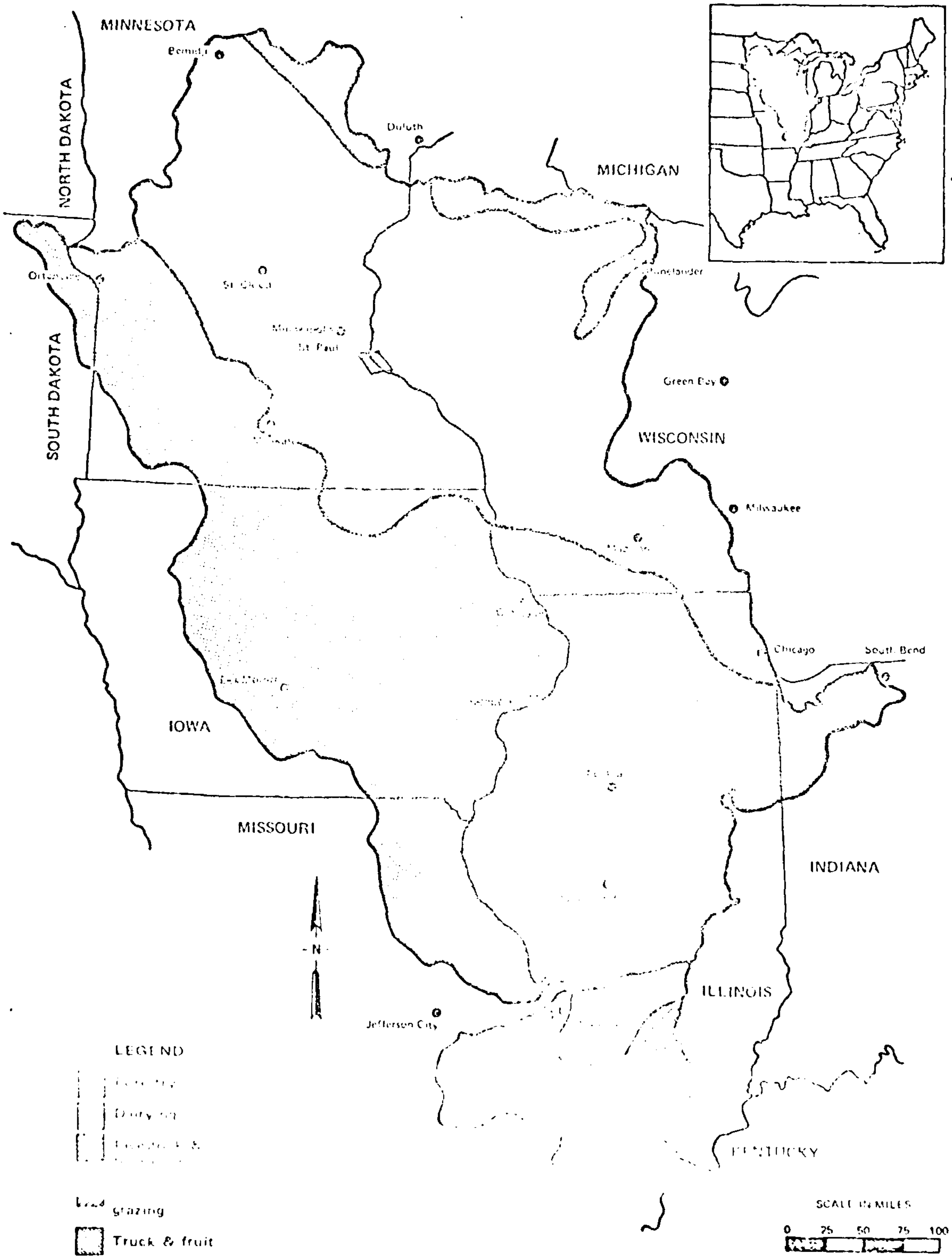


Figure 25. Major types of farming regions
Source: "Soils of the North Central Region of the United States," North Central Regional Publication No. 76, Bulletin 544, June 1960, p. 14.

(modified from UMRCBS, 1970)

if any greatly detailed use is to be made of forestry resources within the pool. The reproductions are excellent and are not out of date.

The current usage of the Pool #3 forested lands are generally as a part of the Gores Pool #3 Wildlife Area, which is managed as a special use area by the Minnesota Department of Natural Resources. Forest areas are generally zoned as "recreational" in the pool.

There are three loosely defined forest habitats in the cross-section of Pool #3 crossing from Minnesota to Wisconsin. First, are River Bottom Forests which are most obvious, second are Sandy shores and Mudflats, and third are the upland Hardwood forests.

The River Bottom Forests occur adjacent to rivers and mainly are found on flood plains. The common names of the principal woody plants are: Elm, Ash, Cottonwood, Box Elder, Oaks, Basswood, Soft Maple, Willows, Aspen, some Pines, Hackberry, and Arbor Vitae. The Herbaceous component consists of: smartweed, wild millet, fall panicum, cockleburr, and tealgrass.

The sandy shores and mudflats have Willows, Cottonwoods, and some Elms as woody portions. The herbaceous and shrub-like flora are: the same herbs as seen in the River Bottoms plus sedges, carex, canary reed grasses, wild rice, and many of the emergent vegetation expected [illegible].

In the upland Hardwood Forests, the common woody components of

the habitat includes: Bur, White, Red and Black Oaks; Elm; Basswood, with Maples as a dominant; Ash; Hornbeam; Aspen; Birch; Wild Cherry; Hickory; Butternut and Black Walnut.

Wildlife

The Fauna, as well as the Flora, of the upper Mississippi River headwaters and river waterways, are very diverse. This area of the mid-continent of the United States results in the overlapping of the ranges of the Eastern with the Western species. An interspersion of life zones and varied habitat types, ranging from river bottom deciduous forests to marshlands, large open pools, and hill prairies of the upper elevations, all of which attract a wide variety of animal life. About 56 species of mammals, including game and non-game species, are now extinct or are no longer *range* in this area, although this was a portion of their original range.

As of 1960, the list of game animals, fur bearers, and game birds for the upper Mississippi River basin included those found in Table 13.

The general animal population mix now considered as being present in the Pool #3 area includes about 46 mammals, 285 birds, and 35 forms of Amphibians and Reptiles. Over ten species of the larger game and predatory mammal species have disappeared from the pool area. Of the Avifauna, a single species seems to have been extirpated, the Passenger Pigeon. Three other birds are considered on the endangered list. Otherwise, most of the other animal life present at settlement of the white

Table 13. Game Animals, Game Birds, and Furbearers of the Upper Mississippi River Basin, 1960 (modified from UMRCBS, 1970)

Moose[a]	*Alces alces*	Rock Dove	*Columba livia*
Whitetail Deer[a]	*Odocoileus virginianus*	Woodcock[a]	*Philohela minor*
Antelope[a]	*Antilocapra americana*	Common Snipe[a]	*Capella gallinago*
Black Bear[a]	*Ursus americanus*	King Rail[a]	*Rallus elegans*
Snowshoe Hare[a]	*Lepus americanus*	Virginia Rail[a]	*Rallus limicola*
Whitetail Jackrabbit[a]	*Lepus townsendi*	Sora Rail[a]	*Porzana carolina*
Swamp Rabbit[a]	*Sylvilagus aquaticus*	Canada Goose	*Branta canadensis*
E. Cottontail Rabbit[a]	*Sylvilagus floridanus*	Snow Goose	*Chen hyperborea*
E. Fox Squirrel[a]	*Sciurus niger*	Blue Goose	*Chen caerulescens*
E. Gray Squirrel[a]	*Sciurus carolinensis*	Mallard	*Anas platyrhynchos*
Red Fox[a]	*Vulpes fulva*	Black Duck	*Anas rubripes*
Gray Fox[a]	*Urocyon cinereoargenteus*	Gadwall	*Anas strepera*
Raccoon[a]	*Procyon lotor*	Pintail	*Anas acuta*
Opossum[a]	*Didelphis marsupialis*	Green winged Teal	*Anas carolinensis*
Mink	*Mustela vison*	Blue winged Teal	*Anas discors*
River Otter	*Lutra canadensis*	American Widgeon	*Mareca americana*
Least Weasel	*Mustela rixosa*	Shoveler	*Spatula clypeata*
Shorttail Weasel	*Mustela erminea*	Wood Duck	*Aix sponsa*
Longtail Weasel	*Mustela frenata*	Redhead	*Aythya americana*
Striped Skunk	*Mephitis mephitis*	Canvasback	*Aythya valisineria*
Spotted Skunk	*Spilogale putorius*	Lesser Scaup	*Aythya affinis*
Beaver[a]	*Castor canadensis*	Ring necked Duck	*Aythya collaris*
Muskrat[a]	*Ondatra zibethica*	Bufflehead	*Bucephala albeola*
Ruffed Grouse[a]	*Bonasa umbellus*	Ruddy Duck	*Oxyura jamaicensis*
Sharp tailed Grouse[a]	*Pedioecetes phasianellus*	Common Merganser	*Mergus merganser*
Bobwhite Quail[a]	*Colinus virginianus*	Red breasted Merganser	*Mergus serrator*
Hungarian Partridge[a]	*Perdix perdix*	Hooded Merganser	*Lophodytes cucullatus*
Ring necked Pheasant[a]	*Phasianus colchicus*	Coot	*Fulica americana*
Wild Turkey[a]	*Meleagris gallopavo*	Common Gallinule	*Gallinula chloropus*
Mourning Dove[a]	*Zenaidura macroura*		

man remains present, although, in very reduced numbers.

The Pool #3 terrestrial forms of wildlife are dispersed according to habitat and vegetation zones of preferences for the various species. In the marshes are to be found the aquatic mammals, grebes, rails, waterfowl, and smaller bird life unadapted to wading or swimming, yet inhabiting the zone. Terns, blackbirds, Amphibians and Reptiles are common.

In the Damp Meadows, marsh-songbirds, herons, rails, a few water-fowl, and the Amphibians and Reptiles are seen.

In the sandy shorelines and mudflats are some typical shorebirds, a few waterfowl species, and aquatic mammals. The Riverbottom Forests contain deer, songbirds, and smaller woodland mammals.

The Upland Forests contain deer, small mammals, some Amphibia, Reptiles, and songbirds. The Hill Prairies contain ground nesting bird species, a few Reptiles, gophers and mice.

The birds of the Pool #3 region number about 285 species. There are about 97 considered as summer residents and/or nesting species. The rest constitute [illegible] occasional migrants, or those of variable status, including [illegible] rare or accidental occurence. As with other wildlife of [illegible] region, the overlapping [illegible] [illegible] stern areas of the United States, as well as the varied habitats afforded by the Mississippi River Valley both contribute to the large numbers of species identified

in and around Pool #3. One swan, four kinds of geese, and 26 kinds of ducks have been observed in the area. Birds of prey, including the Southern form of the Bald Eagle are well represented. Rails, many species of shore-birds, gulls, and terns are abundant in the marshes and pool areas. Table 14 lists the birds of the area with common names supplied by the Bell Museum of the University of Minnesota.

The birds on the Endangered Species list which are found in the Pool #3 area are: Southern Bald Eagle (*Haliaetus leucocephalus*) a migrant; American Peregrine Falcon (*Falco peregrinus anatum*), and the Osprey (*Pandion haliaetus*). The Bald Eagle has been photographed feeding at Lock and Dam #3 for about two weeks each Fall.

The Mammalia of Pool #3 are listed in Table 15 as indicated by sightings, range maps, or local collection records. The list is derived from the Mammals of Minnesota (Gunderson, 1953). Further cross checking with leaflet #326 of the USDI, Bureau of Sport Fisheries and Wildlife entitled *Mammals of the Upper Mississippi Refuge*, will point out other animals. The refuge does not include Pool #3, but is close enough to the pool so as to be indicative of those species likely to be present.

Only one species of Mammals is listed as being endangered in the near vicinity of Pool #3. It is the Indiana Bat (*Myotis sodalis*), whose actual existence in Pool #3 has not been demonstrated.

Table 14. List of Birds of the Pool #3 Region.

Loon
Red-throated Loon
Holboell's Grebe
Horned Grebe
Eared Grebe
Pied-billed Grebe
White Pelican
Double-cr. Cormorant
Great Blue Heron
American Egret
Green Heron
Bl. cr. Night Heron
American Bittern
Least Bittern
Whistling Swan
Canada Goose
White-fronted Goose
Snow-Blue Goose
Black Duck
Mallard
Gadwall
Baldpate
American Pintail
Green-winged Teal
Blue-winged Teal
Cinnamon Teal
Shoveler
Wood Duck
Red Head
Ring-necked Duck
Canvas-back
Lesser Scaup Duck
Greater Scaup Duck
Golden-eye
Barrow's Golden eye
Buffle-head
Old Squaw
White-winged Scoter
Surf Scoter
American Scoter
Ruddy Duck
Hooded Merganser
American Merganser
Red-breasted Merganser
Turkey Vulture
Swallow-tailed Kite
Goshawk
Sharp-shinned Hawk
Cooper's Hawk
Red-tailed Hawk
Red-shouldered Hawk
Broad-winged Hawk
Rough-legged Hawk
Ferruginous Rough-leg
Golden Eagle
Bald Eagle
Marsh Hawk
Osprey
Gyrfalcon
Duck Hawk
Pigeon Hawk
Sparrow Hawk
Ruffed Grouse
Prairie Chicken
Sharp-tailed Grouse
European Partridge
Ring-necked Pheasant
Bob-white
Sandhill Crane
King Rail
Virginia Rail
Sora
Yellow Rail
Florida Gallinule
Coot
Piping Plover
Semipalmated Plover
Killdeer
Golden Plover
Black-bellied Plover
Ruddy Turnstone
Woodcock
Wilson's Snipe
Upland Plover
Spotted Sandpiper
Solitary Sandpiper
Western Willet
Greater Yellow-legs
Lesser Yellow-legs
Knot
Pectoral Sandpiper
White-rumped Sandpiper
Baird's Sandpiper
Least Sandpiper
Red-backed Sandpiper
Dowitcher

Table 14. List of Birds of the Pool #3 Region (Continued).

Stilt Sandpiper
Semipalmated Sandpiper
Buff-breasted Sandpiper
Marbled Godwit
Hudsonian Godwit
Sanderling
Avocet
Wilson's Phalarope
Northern Phalarope
Herring Gull
Ring-billed Gull
Franklin's Gull
Bonaparte's Gull
Forster's Tern
Common Tern
Least Tern
Caspian Tern
Black Tern
Mourning Dove
Rock Dove
Yellow-billed Cuckoo
Black-billed Cuckoo
Screech Owl
Great Horned Owl
Snowy Owl
Hawk Owl
Barred Owl
Great Gray Owl
Long-eared Owl
Short-eared Owl
Saw-Whet Owl
Whip-poor-will
Night Hawk
Chimney Swift
Rub-th'd Hummingbird
Belted Kingfisher
Flicker
Pileated Woodpecker
Red-bellied Woodpecker
Red-headed Woodpecker
Yellow-bellied Sapsucker
Hairy Woodpecker
Downy Woodpecker
Artic 3-toed Woodpecker
King bird
Western Kingbird
Crested Flycatcher
Yellow-bellied Flycatcher
Alder Flycatcher
Least Flycatcher
Wood Pewee
Olive-sided Flycatcher
Horned Lark
Tree Swallow
Bank Swallow
Rough-winged Swallow
Barn Swallow
Cliff Swallow
Purple Martin
Canada Jay
Blue Jay
Magpie
Raven
Crow
Black-capped Chickadee
Hudsonian Chickadee
Tufted Titmouse
White-breasted Nuthatch
Red-breasted Nuthatch
Brown Creeper
House Wren
Winter Wren
Bewick's Wren
Carolina Wren
Long-billed Marsh Wren
Short-billed Marsh Wren
Mockingbird
Cat Bird
Brown thrasher
Robin
Wood Thrush
Hermit Thrush
Olive-backed Thrush
Gray-checked Thrush
Veery
Bluebird
Townsend's Solitaire
Blue-gray Gnatcatcher
Golden-crowned Kinglet
Ruby-crowned Kinglet
American Pipit
Bohemian Waxwing
Cedar Waxwing
Northern Shrike

Table 14. List of Birds of the Pool #3 Region (Continued).

Phoebe
Starling
Bell's Vireo
Yellow-throated Vireo
Blue-headed Vireo
Red-eyed Vireo
Philadelphia Vireo
Warbling Vireo
Black & White Warbler
Prothonotary Warbler
Worm-eating Warbler
Golden-winged Warbler
Blue-winged Warbler
Tennessee Warbler
Orange-crowned Warbler
Nashville Warbler
Parula Warbler
Yellow Warbler
Matnolia Warbler
Camp May Warbler
Black-th'd Blue Warbler
Myrtle Warbler
Audobon's Warbler
Black-th'd Green Warbler
Cerulean Warbler
Blackburnian Warbler
Hooded Warbler
Chestnut-sided Warbler
Bay-breasted Warbler
Black-poll Warbler
Pine Warbler
Palm Warbler
Oven-bird
Northern Water-Thrush
Louisiana Water-Thrush
Connecticut Warbler
Mourning Warbler
Yellow-throat
Yellow-breasted Chat
Wilson's Warbler
[illegible]
Redstart
English Sparrow
Bobolink
Eastern Meadowlark
Western Meadowlark
Yellow-headed Blackbird
Red-winged Blackbird
Orchard Oriole

Migrant Shrike
Baltimore Oriole
Rusty Blackbird
Brewer's Blackbird
Bronzed Grackle
Cowbird
Scarlet Tanager
Cardinal
Rose-breasted Grosbeak
Indigo Bunting
Dickcissel
Evening Grosbeak
Purple Finch
Pine Grosbeak
Hoary Redpoll
Redpoll
Pine Siskin
Goldfinch
Red Crossbill
White-winged Crossbill
Towhee
Savannah Sparrow
Grasshopper Sparrow
Leconte's Sparrow
Henslow's Sparrow
Nelson's Sparrow
Vesper Sparrow
Lark Sparrow
Slate-colored Junco
Oregon Junco
Tree Sparrow
Chipping Sparrow
Clay-colored Sparrow
Field Sparrow
Harris' Sparrow
White-crowned Sparrow
White-throated Sparrow
Fox Sparrow
[illegible]
[illegible]
[illegible]
Lapland Longspur
Snow Bunting
Western Grebe
Yellow Night Heron
Western Tanager

Mammals of the Pool #3 area are as follows indicated in range maps, sightings, or local collection records in "The Mammals of Minnesota" (Gunderson, 1953, University of Minnesota), USDI Refuge Leaflet No. 326 "Mammals of the Upper Mississippi Refuge" also served as a reference. Names and order of the University list appear in Table 15.

Table 15. Mammals of Pool 3

Virginia Opossum (Didelphis virginiana)
Common Mole (Scalopus aquaticus)
Star-nosed Mole (Condylura cristata)
Cinereous Shrew (Sorex cinereus)
Saddle-backed Shrew (Sorex arcticus)
Water Shrew (Sorex palustris)
Pigmy Shrew (Microsorex hoyi)
Short-tailed Shrew (Blarina brevicauda)
Little Brown Bat (Myotis lucifugus)
Keen's Little Brown Bat (Myotis keenii)
Big Brown Bat (Eptisecus fuscus)
Pipistrelle (Pipistrellus subflavus)
Silver-haired Bat (Lasionycteris noctivigans)
Red Bat (Lasiurus borealis)
Hoary Bat (Lasiurus cinereus)
White-tailed Jack Rabbit (Lepus townsendii)
Cottontail Rabbit (Sylvilagus floridanus)
Woodchuck (Marmota monax)
Striped Ground Squirrel (Citellus tridecemlineatus)
Franklin's Ground Squirrel (Citellus franklinii)
Eastern Chipmunk (Tamias striatus)
Red Squirrel (Tamiasciurus hudsonicus)
Gray Squirrel (Sciurus carolinensis)
Fox Squirrel (Sciurus niger)
Southern Flying Squirrel (Glaucomys volans)
Mississippi Valley Pocket Gopher (Geomys bursarius)
Pocket Mouse (Perognathus flavescens)
Beaver (Castor canadensis)
Northern White-footed Mouse (Peromyscus leucopus nov.)
C[illegible] (Microtus pennsylvanicus)
Muskrat (Ondatra zibethica)
Norway Rat (Rattus norvegicus)
House Mouse (Mus musculus)
Meadow Jumping Mouse (Zapus hudsonius)
Raccoon (Procyon lotor)
Short-tailed Weasel (Mustela erminea)

Table 15. Mammals of Pool 3 (Continued).

Long-tailed Weasel (Mustela frenata)
Least Weasel (Mustela rixosa)
Mink (Mustela vison)
Otter (Lutra canadensis)
Spotted Skunk (Spilogale interrupta)
Striped Skunk (Mephitis mephitis)
Badger (Taxidea taxus)
Red Fox (Vulpes fulva)
Gray Fox (Urocyon cinereoargenteus)
White-tailed Deer (Odocoileus virginianus)

A sublisting of the aquatic animals of the Pool #3 region is made as Table 16. Included are a few furbearing species with commercial value.

Table 16. Aquatic Animals of Pool #3 of the Mississippi River

<u>Furbearers</u>	
Beaver	Racoon
Muskrat	Mink
Otter	
<u>Salamanders</u>	
Mud Puppy	Common Newt
Tiger Salamander	
<u>Toads</u>	
American Toad	
<u>Frogs</u>	
Cricket Frog	Swamp Tree Frog
Spring Peeper	Common Tree Frog
Green Frog	Leopard Frog
Wood Frog	
<u>Turtles</u>	
Snapping Turtle	Wood Turtle
Blandings' Turtle	Map Turtle
False Map Turtle	Painted Turtle
Spiny Soft-Shelled Turtle	
<u>Snakes and Lizards</u>	
Black Banded Skink	Six-Lined Race Runner
Common Water Snake	Ring-Necked Snake
Eastern Hognosed Snake	Smooth Green Snake
Blue Racer	Fox Snake
Bull Snake	Milk Snake
DeKays Snake	Red Bellied Snake
Common Garter Snake	Timber Rattle Snake

Of the animals listed in Table 16, only the Racoon and Muskrat exist in sufficient numbers to sustain fur harvests at an annual basis.

The fishes of the Pool #3 area are included in the checklist of fishes of the upper Mississippi River Basin headwaters as seen in Table 17. Tables 18 and 19 list the observed game and rough fishes which have been observed during preoperational studies of the Mississippi biota for Northern States Power Company by St. Mary's College of Winona, Minnesota (Miller, 1971, 1972 and 1973).

Water Quality

Generally, the water quality as it leaves Pool #2 is good. In past years, this has not been true, due to effluent from the Minneapolis/St. Paul Sanitary District (MSSD) which was not always biodegraded by the time the water reached Lock and Dam #2. In cooperation with the MSSD, the Corps increased the aeration capabilities of Dam #2 Tainter Gates to the extent that the Dissolved Oxygen (DO) of Pool #3 seldom drops below the recommended 5 mg/1. In past studies, the waters of Pool #3 have been termed grossly polluted (FWPCA, 1966). Subsequent to the report of the FWPCA, the two greatest floods of record, 1965 and 1969, have passed through Pool #3. Whether the flushing action of two major floods in rapid succession was responsible for an up-grading of the water quality is not easily assignable. The numbers of macroinvertebrates was down as was the number of species present. Clean water indicating organisms were not in a preponderance, and the BOD was high as were the numbers of pollution-tolerant organisms. The series of studies in 1971, 1972 and 1973 for Northern States Power has demonstrated the recolonization of the Mississippi River substrates

Table 17. Checklist of Fishes Found in the Upper Mississippi River Basin (modified from UMRCBS, 1970)

Petromyzontidae – lampreys
- Chestnut lamprey *Ichthyomyzon castaneus* Girard
- Silver lamprey *Ichthyomyzon unicuspis* Hubbs and Trautman

Acipenseridae – sturgeons
- Lake sturgeon *Acipenser fulvescens* Rafinesque
- Pallid sturgeon *Scaphirhynchus albus* (Forbes and Richardson)
- Shovelnose sturgeon *Scaphirhynchus platorynchus* (Rafinesque)

Polyodontidae – paddlefishes
- Paddlefish *Polyodon spathula* (Walbaum)

Lepisosteidae – gars
- Spotted gar *Lepisosteus oculatus* (Winchell)
- Longnose gar *Lepisosteus osseus* (Linnaeus)
- Shortnose gar *Lepisosteus platostomus* Rafinesque

Amiidae – bowfins
- Bowfin *Amia calva* Linnaeus

Clupeidae – herrings
- Skipjack herring *Alosa chrysochloris* (Rafinesque)
- Ohio shad *Alosa ohiensis* Evermann
- Gizzard shad *Dorosoma cepedianum* (LeSueur)
- Threadfin shad *Dorosoma petenense* (Gunther)

Salmonidae – trouts, whitefishes, and graylings
- Cisco or lake herring *Coregonus artedii* LeSueur
- Rainbow trout *Salmo gairdneri* Richardson

Hiodontidae – mooneyes
- Goldeye *Hiodon alosoides* (Rafinesque)
- Mooneye *Hiodon tergisus* LeSueur

Umbridae – mudminnows
- Central mudminnow *Umbra limi* (Kirtland)

Esocidae – pikes
- Grass pickerel *Esox americanus vermiculatus* LeSueur
- Northern pike *Esox lucius* Linnaeus
- Muskellunge *Esox masquinongy* Mitchill

Cyprinidae – minnows and carps
- Stoneroller *Campostoma anomalum* (Rafinesque)
- Southern redbelly dace *Chrosomus erythrogaster* (Rafinesque)
- Carp *Cyprinus carpio* Linnaeus
- Ozark minnow *Dionda nubila* (Forbes)
- Silverjaw minnow *Ericymba buccata* Cope
- Brassy minnow *Hybognathus hankinsoni* Hubbs
- Cypress minnow *Hybognathus hayi* Jordan
- Silvery minnow *Hybognathus nuchalis* Agassiz
- Northern plains minnow *Hybognathus placitas* Girard
- Speckled chub *Hybopsis aestivalis* (Girard)
- Flathead chub *Hybopsis gracilis* (Richardson)
- Sicklefin chub *Hybopsis meeki* Jordan and Evermann
- Silver chub *Hybopsis storeriana* (Kirtland)
- Gravel chub *Hybopsis x-punctata* Hubbs and Crowe
- Golden shiner *Notemigonus crysoleucas* (Mitchill)
- Pallid shiner *Notropis amnis* Hubbs and Greene
- Pugnose shiner *Notropis anogenus* Forbes
- Emerald shiner *Notropis atherinoides* Rafinesque
- River shiner *Notropis blennius* (Girard)
- Ghost shiner *Notropis buchanani* Meek
- Central common shiner *Notropis cornutus chrysocephalus* (Rafinesque)
- Common shiner *Notropis cornutus* (Mitchill)
- Bigmouth shiner *Notropis dorsalis* (Agassiz)
- Spottail shiner *Notropis hudsonius* (Clinton)
- Red shiner *Notropis lutrensis* (Baird and Girard)
- Rosyface shiner *Notropis rubellus* (Agassiz)
- Silverband shiner *Notropis shumardi*
- Spotfin shiner *Notropis spilopterus* (Cope)
- Sand shiner *Notropis stramineus* (Cope)
- Weed shiner *Notropis texanus* (Girard)
- Blacktail shiner *Notropis venustus* (Girard)
- Mimic shiner *Notropis volucellus* (Cope)
- Channel mimic shiner *Notropis volucellus wickliffi* Trautman
- Pugnose minnow *Opsopoeodus emiliae* Hay
- Suckermouth minnow *Phenacobius mirabilis* (Girard)
- Bluntnose minnow *Pimephales notatus* (Rafinesque)
- Fathead minnow *Pimephales promelas* Rafinesque
- Bullhead minnow *Pimpephales vigilax* (Baird and Girard)
- Longnose dace *Rhinichthys cataractae* (Valenciennes)
- Creek chub *Semotilus atromaculatus* (Mitchill)

Catostomidae – suckers
- River carpsucker *Carpiodes carpio* (Rafinesque)
- Quillback *Carpiodes cyprinus* (LeSueur)
- Highfin carpsucker *Carpiodes velifer* (Rafinesque)
- White sucker *Catostomus commersoni* (Lacepede)
- Blue sucker *Cycleptus elongatus* (LeSueur)
- Northern hog sucker *Hypentelium nigricans* (LeSueur)
- Smallmouth buffalo *Ictiobus bubalus* (Rafinesque)
- Bigmouth buffalo *Ictiobus cyprinellus* (Valenciennes)
- Black buffalo *Ictiobus niger* (Rafinesque)
- Spotted sucker *Minytrema melanops* (Rafinesque)
- Silver redhorse *Moxostoma anisurum* (Rafinesque)
- Golden redhorse *Moxostoma erythrurum* (Rafinesque)
- Northern redhorse *Moxostoma macrolepidotum* (LeSueur)
- Greater redhorse *Moxostoma valenciennesi* Jordan

Table 17. Checklist of Fishes Found in the Upper Mississippi River Basin (Continued).

Ictaluridae – freshwater catfishes
- Blue catfish *Ictalurus furcatus* (LeSueur)
- Black bullhead *Ictalurus melas* (Rafinesque)
- Yellow bullhead *Ictalurus natalis* (LeSueur)
- Brown bullhead *Ictalurus nebulosus* (LeSueur)
- Channel catfish *Ictalurus punctatus* (Rafinesque)
- Stonecat *Noturus flavus* Rafinesque
- Tadpole madtom *Noturus gyrinus* (Mitchill)
- Flathead catfish *Pylodictis olivaris* (Rafinesque)

Anguilliade – freshwater eels
- American eel *Anguilla rostrata* (LeSueur)

Cyprinodontidae – killifishes
- Blackstripe topminnow *Fundulus notatus* (Rafinesque)

Poeciliidae – livebearers
- Mosquitofish *Gambusia affinis* (Baird and Girard)

Gadidae – cods and hakes
- Burbot *Lota lota* (Linnaeus)

Gasterosteidae – sticklebacks
- Brook stickleback *Eucalia inconstans* (Kirtland)

Percopsidae – trout perches
- Trout-perch *Percopsis omiscomaycus* (Walbaum)

Aphredoderidae – pirate perches
- Pirate perch *Aphredoderus sayanus* (Gilliams)

Serranidae – sea basses
- White bass *Roccus chrysops* (Rafinesque)
- Yellow bass *Roccus mississippiensis* (Jordan and Eigenmann)

Centrarchidae – sunfishes
- Rock bass *Ambloplites rupestris* (Rafinesque)
- Warmouth *Chaenobryttus gulosus* (Cuvier)
- Green sunfish *Lepomis cyanellus* Rafinesque
- Pumpkinseed *Lepomis gibbosus* Rafinesque
- Orangespotted sunfish *Lepomis humilis* (Girard)
- Bluegill *Lepomis macrochirus* Rafinesque
- Longear sunfish *Lepomis megalotis* (Rafinesque)
- Redear sunfish *Lepomis microlophus* (Gunther)
- Smallmouth bass *Micropterus dolomieui* Lacepede
- Largemouth bass *Micropterus salmoides* (Lacepede)
- White crappie *Pomoxis annularis* Rafinesque
- Black crappie *Pomoxis nigromaculatus* (LeSueur)

Percidae – perches
- Crystal darter *Ammocrypta asprella* (Jordan)
- Western sand darter *Ammocrypta clara* Jordan and Meek
- Mud darter *Etheostoma asprigene* (Forbes)
- Rainbow darter *Etheostoma caeruleum* Storer
- Bluntnose darter *Etheostoma chlorosomum* (Hay)
- Iowa darter *Etheostoma exile* (Girard)
- Fantail darter *Etheostoma flabellare* Rafinesque
- Johnny darter *Etheostoma nigrum* Rafinesque
- Banded darter *Etheostoma zonale* (Cope)
- Yellow perch *Perca flavescens* (Mitchill)
- Logperch *Percina caprodes* (Rafinesque)
- Blackside darter *Percina maculata* (Girard)
- Slenderhead darter *Percina phoxocephala* (Nelson)
- River darter *Percina shumardi* (Girard)
- Sauger *Stizostedion canadense* (Smith)
- Walleye *Stizostedion vitreum vitreum* (Mitchill)

Sciaenidae – drums
- Freshwater drum *Aplodinotus grunniens* Rafinesque

Atherinidae – silversides
- Brook silverside *Labidesthes sicculus* (Cope)

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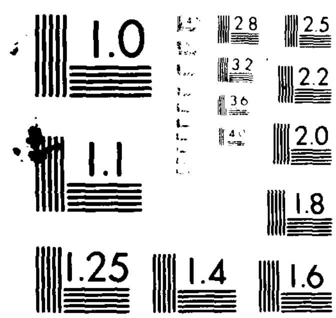


MICROCOPY RESOLUTION TEST CHART

Table 18. Observed Game and Rough Fish Species and Proportions in the Pool 3 Vicinity During 1970 and 1971

Species	Location			
	Islands	Sturgeon Lake	Pool 3 (Above Dam No. 3)	Pool 4 (Below Dam No. 3)
Largemouth bass	x	x	x	x
Rock bass	x	x	x	x
Smallmouth bass		x		x
White bass	x	x	x	x
Bluegill	x		x	
Yellow bullhead		x		x
Channel catfish	x	x	x	x
Flathead catfish	x		x	
Black crappie		x		x
White crappie	x		x	
Mooneye		x		x
Northern pike	x		x	
Sauger	x	x	x	x
Walleye	x	x	x	x
Total game species, %	29	13	34	84
Bowfin (Dogfish)	x	x	x	x
Largemouth buffalo		x		x
Smallmouth buffalo	x	x	x	x
Carp	x	x	x	x
Freshwater drum	x	x	x	x
Shortnose gar		x		x
Greater redhorse	x		x	
Shorthead redhorse	x		x	
Silver redhorse	x	x	x	x
Gizzard shad	x		x	
Total rough species, %	71	87	66	16

Table 19. Game and Rough Fish Proportions in 1970 and 1971. Samplings Near the Pool #3.

Location	Method	Fish Distribution, % Game	Rough
Sturgeon Lake	Electrofishing	12.7	87.3
Below Lock and Dam #3	Electrofishing	83.5	16.5
Above Lock and Dam #3	Trapnetting	34	.66
Islands at Plant Site	Trapnetting	29	71

by large numbers of Trichopterans, Ephemeropterans, and some Plecopterans as well as many Dipterans. The presence of those which are univoltine species is indicative of "clean waters" at the current time. Miller has termed the area as being a "recovery-zone" after the pollutants from the Twin Cities (Miller, 1971). The high water quality of the major tributary, the St. Croix River at Prescott, Wisconsin in the upper portion of the pool, has a beneficial effect on the overall water quality of Pool #3 waters. The St. Croix juncture with the Mississippi is the terminus of the first "Wild River" of the United States. The water quality is visibly discernable from an aircraft, in that the clearer waters of the St. Croix can be followed downstream into the Mississippi almost a mile after meeting each other.

The Coliform Bacterial count remains relatively high, and the Minnesota Board of Public Health still classifies the Pool #3 stretch as "whole body contact constitutes a distinct health hazard". Recreational use for water skiing and swimming is widespread downstream of mile 802 of the Corps Navigation Charts.

Aquatic Vegetation

Aquatic vegetation is relatively sparse in the lower portion of Pool #3 as would be expected. There are no great flooded areas other than North Lake and Sturgeon Lake which are aportion of Gores Management area at the upper end, and which is more a lake than marsh as you get into Sturgeon Lake waters. The types of Aquatic macrophytes most

commonly seen are listed in Table 20. The upper portion of the pool (upstream of St. Croix River) is generally high-banked with little marshlands. The most extensive marshland habitat borders North Lake in mid-pool.

The current velocities and constant scouring by commercial navigation and recreational boat traffic deter any growth by submerged or emergent macrophytes along the main stem of the main channel of the Mississippi. The river is relatively narrow in this pool, creating strong wave action on the shorelines.

Invertebrate Fauna

In that macroinvertebrates are frequently considered as water quality indicator organisms, a list of the invertebrates found in Pool #3 and downstream of Dam #3 is shown as Table 21. The list is from NSP Environmental Studies in 1971 (Miller, 1972). There is a great diversity, with many clean water indicators.

Table 20. Aquatic Macrophytes in Pool #3

Family	Genus and Species	Family	Genus and Species
Alismaceae		Najadaceae	
	Sagitaria latifolia	(pondweed)	Potamogeton pectinatus
	(Arrowhead)		Potamogeton crispus
Butomaceae		Polygonaceae	
	Anacharis	(Pondweed)	Polygonum natans
	(Waterweed, Elodea)		
	Vallisneria americana		
Gramineae		Salicaceae	
	Zizania aquatica		Saliz spp.
	(Wild rice)		(Willow)
Cyperaceae		Typhaceae	
(Sedges)	Eleocharis spp.		Typha latifolia
	Scirpus spp.		(Cattail)
Lemnaceae			
(Duckweed)	Lemna minor		
	Spirodella polyrhiza		
	Wolffia punctata		

Table 21. Macroinvertebrates Collected in the Mississippi River Study Area at Prairie Island Nuclear Generating Station (1971)

Key

Transect identification remains as enumerated in Figures I - IV.

First letter = Sector of river
hyphen
third position numeral = area within a sector
Second letter = portion of transect sampled
W = Wisconsin shore areas
M = Minnesota shore areas
C = Center of channel
parenthetical numbers = month of year sample selected.
6 = June
7 = July
10 = October, etc.

Example: B-2M (6, 9, 10) indicates a sample taken from the B-2 transect on the Minnesota shore, with specimens found in June, September, October.

SPONGES:

1. Spongillidae
A-1M (6, 7); B-1W (6, 7); B-2C (6, 7); C-1M (6, 7); C-1W (6, 7); E-3W (6).

FLATWORMS:

2. *Dugesia tigrinum*
A-1M (6, 7); A-1W (6, 7); B-1M (6, 7); B-1W (6, 7); B-2C (6,7); C-1M (6, 7); C-1W (6, 7, 8); C-3M (6, 7, 8); C-4M (6, 7, 8); C-4W (6, 7, 8); D-1M (6, 7); D-1W (6, 7, 8); D-2M 6, 7); D-2W (6, 7, 8); D-3M (6, 7); D-3W (6, 7, 8); E-1M (6,7); E-1W (6, 7, 8); E-2C (6, 7, 8); F-[illegible] (6, 7, [illegible]); [illegible]; F-1M (6, 8); F-1W (6, 7, 8); G-1M (6, 7, 8).

BRYOZOANS:

3. *Cristatella mucedo*
A-1M (7); E-1M (7); E-2C (7); G-1C (7).

4. *Plumatella repens*
A-1M (7); E-1M (7); A-2M (8); B-1M (7, 8); C-1M (8); C-4M (6, 7); D-1M (7, 8); D-2M (8); E-1M (7, 8); E-3M (8).

Table 21. (Continued)

WORMS:

5. Haplotaxidae
A-2M (7, 8); B-2C (7).

6. Branchiura sowerbyi
B-2C (7).

7. Tubifex tubifex
A-1W (7, 8); A-2M (7, 8); A-2W (7, 8); B-1M (8); B-1W (7, 8, 9); B-2C (8); C-1W (7, 8); C-3M (7, 8, 9); C-3W (8); C-4W (8, 9); D-1M (8, 9); D-2M (7, 8); D-3M (8, 9); E-1M (7, 8); E-3W (8, 9); F-1M (8, 9); G-1C (7, 8, 9).

LEECHES:

8. Dina cf. fervida
A-1M (7).

9. Dina spp.
A-1M (7); D-2W (8).

10. Erpobdella punctata
B-1M (7); B-1W (7); C-1W (8); C-3M (8); C-4M (7, 8); C-4W (7); D-3W (7); E-1M (7).

11. Erpobdella spp.
A-1W (7).

12. Glossiphonia complanata
D-2W (7).

13. Helobdella fusca
A-1W (7); C-4W (7); D-1W (7); D-2W (7).

14. Helobdella stagnalis
A-1W (7, 8); E-1M (8); C-4W (7).

15. Placobdella montifera
D-1W (7, 8); D-3M (8); D-3W (8).

16. Placobdella parasitica
A-1W (7); B-2C (7); C-4W (7); D-1W (8); E-1W (8).

17. Placobdella reducta
A-2W (7).

18. Placobdella rugosa
C-4W (7); D-1W (7); D-2W (7); E-2M (7); G-1C (7).

Table 21. (Continued)

SNAILS:

19. *Pleurocera* cf. *acuta*
A-1W (7, 8); C-3M (8, 9); A-2M (8); B-1M (8); C-3M (8); E-2M (8).

20. *Ferrissia fusca*
A-1W (8); C-3M (8); G-1M (8).

21. *Ferrissia* sp. 1
A-1W (6); B-1M (6); B-2C (6, 7); C-1M (6, 7); C-1W (6, 7); C-3M (6); C-3W (7); C-4M (6, 7).

22. *Gyraulus* sp. 1
A-1W (7, 8).

CLAMS:

23. *Amblema raraplicata*
Sturgeon Lake; E-1M (7, 8); E-2 (7); F-1M (7).

24. *Quadrula pustulosa* (pimpleback)
Sturgeon Lake; E-2M (7, 8); E-1M (8).

25. *Pleurobema coccineum mississipiensis*
Sturgeon Lake; D-2W (7, 8).

26. *Lampsilis siliquoidea (pepinensis)* (Fat Mucket)
F-1W (8).

27. *Lampsilis ovata ventricosa* (Pocketbook)
F-1M (7).

28. *Proptera alata*
Sturgeon Lake; C-3 (8).

29. *Fusconia undata* (Pigtoe)
C-1W (7, 8); F-1W (8, 9).

30. *Musculium* spp.
A-1M (6, 7, 8, 9); A-2M (7, 8, 9); C-1W (7, 8, 9); F-1M (8, 9); G-1C (8).

31. *Pisidium* spp.
C-1W (7, 8, 9); C-3M (8, 9).

32. *Anodonta gigantea*
E-2C (Vermillion River) (9).

Table 21. (Continued)

AMPHIPODS:

33. *Hyalella azteca*
A-1M (6, 7); A-1W (6); A-2W (6); B-1M (6, 7, 8); B-2C (6, 7); C-1M (6); C-1W (6); C-3M (6); C-4M (6); C-4W (6); D-1M (6); D-1W (6); D-2M (6, 7); D-2W (6); D-3M (6); D-3W (6); E-1W (6); E-2C (6, 7); E-3W (6, 7); F-1M (6); G-1C (6, 7).

34. *Gammarus* spp.
A-1W (6, 7, 8); A-2W (7, 8); C-3C (8, 9).

ISOPODS:

35. *Asellus militaris*
A-1M (6); A-1W (6); B-1M (6, 7, 8); B-1W (6); B-2C (6); C-1W (6); C-3M (6); C-4M (6, 7, 8); C-4W (6, 7, 8); D-1M (6); D-1W (6); D-2M (6, 7, 8); D-2W (6); D-3W (6, 7, 8); E-1M (6, 7, 8); E-2C (7); E-3W (6).

36. *Asellus* sp. 1
A-1W (6); E-1W (6).

CRAYFISH:

37. *Orconectes virilis*
B-2C (6); observed very frequently on the lower portions of the islands dividing main channel from Sturgeon Lake.

STONEFLIES:

NONE OBSERVED IN THE 1971 STUDY

MAYFLIES:

38. *Amaletus lineatus*
B-2C (7); C-4W (7, 8).

39. *Amaletus ludens*
C-4W (7, 8); D-1M (7); D-2W (7, 8); D-3M (7, 8); D-3W (7, 8, 9); G-1C (7).

40. *Amaletus* sp. 1
A-2M (7, 8); A-2W (7); B-1W (7, 8); B-2C (7); C-4M (6); C-4W (7); D-1M (7, 8); D-1W (7, 8); D-2W (7); D-3M (6, 7, 8); F-1M (7); F-1W (6); G-1C (7, 8).

41. *Baetis bruneicolor*
D-3W (6).

42. *Baetis intercalaris*
B-2M (7); D-3W (7).

Table 21. (Continued)

43. *Baetis* sp. 1
A-2W (7); D-3W (6); G-1C (7).

44. *Caenis* sp. 1
A-1M (6, 7, 8); A-1W (6, 7, 8); A-2M (7); A-2W (7, 8);
B-1M (7); B-1W (6, 7, 8); B-2C (6, 7, 8); C-1M (6); C-1W (6, 7);
C-4W (7); D-1M (7, 8); D-1W (7); D-2M (7); D-2W (6); D-3W (6);
E-1M (7); E-3M (6); E-3W (6, 7, 8); F-1W (6).

45. *Ephemerella temporalis*
E-3W (6).

46. *Ephemerella* sp. 1
E-3W (6).

47. *Paraleptophlebia* sp. 1
A-1W (6); A-2M (6); C-1M (6).

48. *Pseudocloeon myrsum*
G-1C (7).

49. *Pseudocloeon parvulum*
C-4W (7); D-1M (7); D-1W (6); G-1C (7, 8).

50. *Pseudocloeon* sp. 1
D-1M (7).

51. *Tricorythodes atratus*
A-1W (7); A-2M (7); C-1M (6); C-4W (7); D-1M (6, 7); D-1W (7);
D-2W (7); D-3M (6); E-2M (6); E-3W (6); G-1C (6, 7).

52. *Tricorythodes* sp. 1
A-1W (7); A-2W (7); D-1W (6); E-3W (7).

53. *Potamanthus* sp. 1
A-1W (7); A-2W (7); E-1M (6); E-2M (6); E-3W (6); G-1C (6, 7).

54. *Campsurus* sp. 1
A-1M (6).

55. *Heptagenia aphrodite*
E-3W (7).

56. *Heptagenia diabasia*
A-1M (6); A-1W (6); B-2C (6); D-2W (6); D-3W (6); E-2M (6);
F-1M (6); G-1C (6).

Table 21. (Continued)

57. *Heptagenia flavescens*
A-2M (7); A-2W (7); B-2C (7); C-1W (7); C-4M (6); D-1M (7); D-1W (6, 7); D-2W (7); D-3M (6, 7); F-1M (7); F-1W (7).

58. *Heptagenia juno*
A-1W (6).

59. *Heptagenia maculopennis*
A-1M (6); A-1W (6); B-2C (7); C-1M (6); D-1W (6).

60. *Heptagenia marginalis*
A-1M (6); B-2C (7); D-1W (7); D-2W (7); E-3W (6); F-1M (7).

61. *Stenonema ares*
A-1M (6, 7, 8); A-1W (7); A-2W (7, 8); B-1M (7); B-1W (6, 7); B-2C (6, 7); C-1M (6, 7); C-1W (6, 7); C-3M (7); C-4M (6, 7); C-4W (7); D-1M (6, 7); D-1W (7); D-2M (6, 7); D-2W (6, 7); D-3M (7); D-3W (6, 7); E-1M (6); E-2M (7); E-3M (7); E-3W (6, 7); F-1M (6, 7); F-1W (6, 7); G-1C (7).

62. *Stenonema canadense*
A-1M (6).

63. *Stenonema candidum*
B-1W (7).

64. *Stenonema carolina* (cf)
A-1M (7); B-2C (7); D-3M (6).

65. *Stenonema femoratum*
A-1W (6); A-2M (6); B-2C (7); C-4M (6); C-4W (7); D-2W (7); D-3M (7); D-3W (7); E-1W (7); E-3M (6, 7); E-3W (6); G-1C (7).

66. *Stenonema gildersleevei*
A-1M (6, 7); A-1W (7); A-2M (7); A-2W (6, 7); B-1M (7); B-1W (6, 7); B-2C (7); C-1M (6, 7); C-1W (6, 7); C-3M (6); C-4M (6); C-4W (7); D-1M (6); D-1W (6, 7); D-2M (6, 7); D-2W (7); D-3M (7); D-3W (6, 7); E-1M (6); E-2C (7); E-3M (6, 7); E-3W (6, 7); F-1W (6, 7).

67. *Stenonema heterotarsale*
A-1M (6).

68. *Stenonema interpunctatum*
A-1M (6).

69. *Stenonema ithaca*
A-1W (7); A-2W (7); B-2C (7); C-1M (7); C-3M (7); C-4W (7); D-1M (7); D-1W (6, 7); D-3M (7); F-1M (7); G-1C (7).

70. *Stenonema lineatus*
C-4M (6).

71. *Stenonema luteum*
A-1M (7); C-4W (7); D-1M (7).

72. *Stenonema nepotellum*
A-1M (6); A-1W (6).

73. *Stenonema pulchellum*
A-1W (7); A-2M (7); B-1M (7); B-2C (7); D-1M (6, 7); D-1W (7); D-2W (7); D-3M (7); E-3W (7); F-1M (7); G-1C (7).

74. *Stenonema rubromaculatum*
C-4W (7).

75. *Stenonema rubrum*
A-2W (7); B-1W (7); B-2C (7); C-1W (7); D-1M (7); D-2W (7); D-3M (7); E-3W (7); F-1M (7).

76. *Stenonema tripunctatum*
A-1W (6); D-3M (6, 7).

77. *Stenonema* sp. 1
A-1M (7); B-1W (7); D-1M (6); D-3M (7).

DRAGONFLIES:

78. *Gomphus* sp. 1
E-2C (7, 8).

DAMSELFLIES:

79. *Amphigrion saucium*
D-2W (6).

80. *Argia emma*
A-1W (6); D-2W (6).

81. *Argia* sp. 1
A-2W (6); B-2C (6); D-2W (6).

CADDISFLIES:

82. *Cheumatopsyche campyla*
D-1M (6).

83. *Cheumatopsyche* sp. 1
A-1M (7); A-2M (7); A-2W (7); B-2C (7); C-1M (6, 7); C-1W (7); C-4W (7); D-1M (6, 7); D-1W (7); D-2W (7); D-3M (6, 7); D-3W (7); E-1W (7); E-2C (6); E-3M (6, 7); E-3W (7); F-1M (7); F-1W (7); G-1C (6, 7).

Table 21. (Continued)

84. *Hydropsyche aerata*
A-1M (7); A-1W (6, 7); A-2M (7); A-2W (7); B-2C (7); C-1M (7); C-4W (7); D-1M (7); D-1W (7); D-2W (7); D-3M (7); D-3W (7); E-1W (7); E-3M (7); F-1M (7); G-1C (7).

85. *Hydropsyche arinale*
F-1M (7).

86. *Hydropsyche bettini*
D-3W (7).

87. *Hydropsyche bifida*
B-2C (7); D-2W (7); E-2C (6).

88. *Hydropsyche caenis*
A-1M (7); A-2W (7).

89. *Hydropsyche frisoni*
D-1M (7); D-1W (7); D-2W (7); D-3M (7); F-1M (6, 7); F-1W (6); G-1C (7).

90. *Hydropsyche hageni*
A-2W (7); F-1M (7).

91. *Hydropsyche orris*
A-1M (7); A-1W (6, 7); A-2M (7); A-2W (6, 7); B-1M (6); B-1W (7); B-2C (7); C-1M (7); C-1W (7); C-3M (7); C-4W (7); D-1M (7); D-1W (6, 7); D-2W (7); D-3M (6, 7); E-1W (7); E-2C (6); E-3M (6, 7); E-3W (6, 7); F-1M (6, 7); F-1W (6, 7); G-1C (6, 7).

92. *Hydropsyche recurvata*
E-3M (7).

93. *Hydropsyche simulans*
A-2W ([illegible]); C-1W ([illegible]); C-4W (7); D-1M ([illegible]); D-1W (6, 7); D-2W (7); F-[illegible] ([illegible]); F-1M (7).

94. *Hydropsyche slossonae*
[illegible] (7); F-1M (7).

95. *Hydropsyche* sp. 1
B-2C (7); F-1W (7).

96. *Macronemum zebratum*
A-2M (6).

97. *Macronemum* sp. 1
A-1M (7); E-1M (7).

Table 21. (Continued)

98. Potamyia flava
F-1W (6).

99. Agraylea multipunctata
A-1M (7); B-1M (7); C-4W (7).

100. Oxyethira sp. 1
A-2M (7).

101. Hydroptilidae spp.
A-1W (7).

102. Neureclipsis crepuscularis
A-1M (6, 7); A-1W (7); A-2M (7); A-2W (7); B-1M (7); B-1W (7); B-2C (6, 7); C-1M (7); C-1W (7); C-3M (7); C-4W (7); D-1M (7); D-1W (7); D-2M (7); D-2W (6, 7); D-3M (7); D-3W (7); E-1W (7); E-3W (7); F-1W (6, 7); G-1C (7).

103. Neureclipsis sp. 1
A-1M (6, 7); A-1W (6, 7); A-2M (6, 7); B-1W (7); B-2C (7); C-1M (7); C-3M (7); C-4W (6, 7); D-1M (6); D-1W (6); D-2W (7); D-3M (6); D-3W (6); E-1W (7); E-2C (7); E-3M (6, 7); E-3W (6, 7); F-1M (7); F-1W (7).

104. Polycentropus centralis
E-3M (6).

105. Polycentropus cinereus
B-1W (6, 7); D-1M (6); D-2M (6, 7); D-3W (6); E-1M (6); E-3M (6).

106. Polycentropus flavus
A-2M (7); E-1M (7).

107. Polycentropus interruptus
A-1M (6, 7); A-1W (7); A-2M (6); A-2W (7); B-1W (7); B-2C (7); C-1M (7); C-1W (7); C-3M (7); C-4M (7); C-4W (6); E-1W (7); E-2C (7); E-3M (7); E-3W (7); F-1M (7); F-1W (7).

108. Polycentropus placidus
D-2M (6).

109. Polycentropus remotus
A-1M (7); A-1W (6, 7); A-2M (7); A-2W (6, 7); B-1M (7); B-1W (7); B-2C (7); C-1M (7); C-1W (7); C-3M (7); C-4W (7); D-1M (7); D-2M (6, 7); D-3M (7); D-3W (7); E-1M (7).

110. Polycentropus sp. 1
A-1M (7); A-2M (7); A-2W (7); B-1W (7); B-2C (7); C-1M (7).

Table 21. (Continued)

111. Psychomyia flavida
C-4W (7); E-1M (7).

112. Athripsodes tarsi punctatus
A-1M (6); A-1W (6); A-2W (6).

113. Leptocella diarina
C-4W (7).

114. Leptocella sp. 1
A-1W (7).

115. Lepidostoma sp. 1
A-1W (6).

116. Limnephilus sp. 1
A-1M (6).

117. Pycnopsyche subfasciata
A-1M (6); A-2W (6); B-1W (6); C-3M (6).

118. Astenophylas argus
B-2C (6).

119. Phryganeidae G.S.
B-1W (6).

BEETLES:

120. Graphoderes sp. 1
B-2C (6).

121. Microcylloepus sp. 1
A-1M (6); A-2M (6); A-2W (6); B-1M (7); C-1W (6); C-4M (6);
E-1W (6).

[illegible]. [illegible] G.S.
C-4M (6).

123. Elsianus sp. 1
A-1W (6).

124. Lara sp 1
B-1M (6, 7); B-2C (7); C-3M (6); C-4W (6); D-3W (7).

125. Narpus sp. 1
A-1W (7); B-2C (6); E-1M (7).

126. Neoelmis sp. 1
E-2C (7).

Table 21. (Continued)

127. Haliplidae G.S.
A-2W (7); C-3M (6).

128. Hydraenidae G.S.
B-2C (6).

129. *Berosus* sp. 1
B-1W (6).

130. *Hydrochus* sp. 1
E-1W (6).

131. *Helophorus* sp. 1
E-2C (6).

132. *Hydrobius* sp. 1
A-1M (6); C-1W (6); D-2W (6).

133. *Neohydrophilus castus*
B-1M (6); B-2C (6); C-3M (6); C-4W (6); D-2M (6).

DIPTERANS:

134. Chironomidae G.S. *Not taxonomically reduced in 1971.
A-1M (6, 7, 8, 9); A-1W (6, 7, 8, 9); A-2M (6, 7, 8, 9);
A-2W (6, 7, 8, 9); B-1M (6, 7, 8, 9); B-1W (6, 7, 8, 9);
B-2C (6, 7, 8, 9); C-1M (6, 7, 8, 9); C-1W (6, 7, 8, 9);
C-3M (6, 7, 8, 9); C-3W (6, 7, 8, 9); C-4M (6, 7, 8, 9);
C-4W (6, 7, 8, 9); D-1M (6, 7, 8, 9); D-2W (6, 7, 8, 9);
D-2M (6, 7, 8, 9); D-2W (6, 7, 8, 9); D-3M (6, 7, 8, 9);
D-3W (6, 7, 8, 9); E-1M (6, 7, 8, 9); E-1W (6, 7, 8, 9);
E-2C (6, 7, 8, 9); E-3M (6, 7, 8, 9); E-3W (6, 7, 8, 9);
F-1M (6, 7, 8, 9); F-1W (6, 7, 8, 9); G-1C (6, 7, 8, 9).

135. Simuliidae G.S.
A-2M (7); A-2W (7); F-1M (7); F-1W (6).

LEPIDOPTERANS:

136. Pyralidae G.S.
E-3M (6).

HEMIPTERANS:

137. *Plea Striola*
B-2C (6).

138. *Tricorixa* sp. 1
B-2C (6).

Table 21. (Continued)

WATER MITES:

139. Hydracarina
A-1W (7); B-1M (6); B-2C (7); C-1M (7); D-1M (7); D-1W (7); D-2W (7); D-3W (7); E-1M (7); E-1W (7); F-1M (7); F-1W (7); G-1C (7).

NEUROPTERANS:

140. Climacia areolaris
B-2C (6).

SOCIOECONOMIC SETTING

The socioeconomic aspects of the environmental setting are discussed (1) by identifying the three-way subdivision of socioeconomic activities used in this report and, (2) by presenting an overview of these activities in Pool #9 as they also relate to the Northern Section of the upper Mississippi River.

Three Subdivisions of Socioeconomic Activities

It is useful tc divide a discussion of the socioeconomic setting of the study area of the upper Mississippi River into (1) industrial activity; (2) recreational activity; and (3) cultural considerations.

Industrial Activity

Industrial activity includes agricultural, manufacturing, transportation, and related pursuits that affect employment and income in the study area directly; this includes employment on farms, in barge operations, commercial dock facilities, lock and dam operations, and commercial fishing. While it is probably most desirable to measure industrial activity in terms of jobs or dollars generated, lack of available data makes this impossible in the present study. As a result indices of this industrial activity - such as tons of commodities moved, industrial facilities constructed, or pounds of fish caught - are generally used.

Recreational Activity

Recreational activity has two effects of interest. One is the psychiological value to the users themselves of being on or near the

Mississippi River for leisure activities. A second effect is the impact of the recreational activity on employment and income. Recreational activity is more indirect in its effect on employment and income than is industrial activity and relates mainly to leisure-time activities of people using the Mississippi River for recreational purposes; examples include boating, sport fishing, hunting, sightseeing, camping, and picnicking. Recreational activities frequently use units of measurement like number of boaters or fishermen using a lake or river, fishing licenses sold, or visitor days. It is often very difficult to find such measures for a particular pool on the Mississippi River. Where such data are available - such as pleasure boat lockages - they are used. Where they are not available - such as fishermen using a specific pool - proxy measurements are used; for example, number of sport fishermen observed annually by lock and dam attendants are taken as a measure of fishing activity in the pools, even though this is not as precise a measure as desired. Problems involved with placing dolar values on these recreational activities are discussed in Section 6.

Cultural Considerations

Cultural considerations are the third component of the socioeconomic setting. These considerations include three kinds of sites of value to society: archaeological sites, historic sites, and contemporary sites. These sites can include such diverse physical assets as burial mounds, historical battlegrounds or buildings, or existing settlements of ethnic groups such as Amish communities. Because of

the difficulty of placing any kind of value on such sites, they are simply inventoried in the present study.

Overview of Socioeconomic Activities in the Study Area

The industrial, recreational, and cultural aspects of Pool #3 are discussed below in relation to the entire Northern Section of the upper Mississippi River to provide a background with which to analyze the impact of operating and maintaining the nine-foot channel in Section 3 of this report.

Industrial Activity

The existence of the Mississippi River and its tributaries has had a profound effect on the industrial development of the American Middle West. It has served as a route of easy access for transportation and communication, tying together the industrialized East with the agricultural Middle West as well as the varied economies of the North and South.

Historical Development of the Waterway

The development of the Northern Section of the upper Mississippi as a waterway for shipment has paralleled the rise of the American economy, keeping pace with the need to move bulk raw materials and heavy, high-volume commodities over the wide geographical areas served by the river network. This has allowed barge transportation to remain competitive with other forms of transportation. It is noteworthy that competing systems of land transportation such as railroads and high-

way trucking utilize the relatively gentle river valley terrain in order to simplify both engineering design and fuel energy demands. Thus, the Mississippi River Valley is intensively utilized to meet the transportation needs of the Midwest.

Long before the coming of the first white settlers, the Mississippi River was a transportation corridor for the Indians. It was used to facilitate the primitive barter economy and as a route for other forms of social and cultural communication and contact.

In its primitive condition, the upper Mississippi was characterized by numerous rapids and rock obstructions. Fluctuations in water flow during various seasons of the year were minor inconveniences to the Indian canoe, but demanded modification before substantial commercial use of the river could take place. Prior to improvements, such traffic was limited to periods of high water when log rafts and small boats could pass between the Falls of St. Anthony and the mouth of the Ohio River.

The neccessity of modifying the natural course of the river to make it suitable for commercial navigation gradually became apparent as the size of the river boats and barges grew. Since the first river steamboat arrived at Fort Snelling in 1823, steamboat transportation for freight and passenger use grew to a peak in the decade 1850 to 1860 when over 1,000 steamboats were active on the entire length of the river. By 1880 the growth of the railroad system in the United

States and the lack of a channel of sufficient depth marked a decline in the use of the river for transportation. However, on the upper reaches of the Mississippi, growth in freight traffic continued. A peak was reached in 1903 with 4.5 million tons moved between St. Paul and the mouth of the Missouri River. A subsequent rapid decline coincided with a drop in river use for moving logs and lumber. In 1916, only 0.5 million tons were shipped on this section of the river.

The last large-scale commercial lumbering ended in Pool #3 about 1914 (Blair, 1930). Through the St. Croix an estimated 12,444,281,720 feet of lumber was rafted out of the St. Croix into Pool #3 from 1837-1915.

The major portion of the rafted logs floated through what is now Pool #3, prior to lock and dam construction. One of the major areas of destination was Winona, Minnesota for its log mills. There was a major sawmill in the Stillwater, Minnesota area in the upper portion of the St. Croix River which is now a part of Pool #3. The sawmill chips and shavings are still a part of the bottom substrate in the vicinity of the Allen King Power Plant on the St. Croix River.

As the population and industry of the upper Midwest region grew, there was a corresponding growth in the need for cheap coal for power generation. A technological consequence of this need was the development of the barge and towboat which gradually replaced the steamboat on the river. The barge and towboat required a deeper channel than

the earlier steamboats. The need for coal in the Upper Midwest was complemented by the need to ship large quantities of grain south to other centers of population. Thus, economies were realized by having at least partially compensating cargoes going both directions on the upper reaches of the river. In the later 1920's large grain shipments from Minneapolis began.

Although four-foot and six-foot channels had been authorized in recognition of the increasing role of the river in the transportation network of the U.S. and technological developments in barges and tugs led to the authorization of a nine-foot channel to Minneapolis in 1930. By 1940 the channel and the requisite locks and dams were essentially complete.

When figures for tonnages shipped at various times on the Mississippi River are examined, it is difficult to make comparisons that relate to Corps' activities. For example, the following factors complicate the problem of data analysis during the period prior to 1940:

1. Statistical data collected by the Corps of Engineers covered different segments of the Upper Mississippi River during these years. Some of the reasons for this appear to be changes in the administration of river segments during that time, as well as some experimentation with better methods of statistical collection.
2. Shipping in the Upper Mississippi was distorted during the decade of the 1930's due to the construction of locks and

dams in the St. Paul District.

3. From 1941 to 1945 all forms of transportation were utilized for the war effort without regard to maximizing economic return. Therefore, data for these years (as with the 1930's) does not necessarily reflect a normal peroid of transportation on the Upper Mississippi.

Barge Shipments. Table 22 shows tonnage information available for selected years from 1920 through 1945 for the river segment identified in the third column of the table.

Table 22. River Shipment from 1920 Through 1945

Year	Total Tonnage (short tons) Shipments and Receipts*	River Segment
1920	630,951	Mpls. to Mouth of Missouri River
1925	908,005	Mpls. to Mouth of Missouri River
1926	691,637	Mpls. to Mouth of Missouri River
1927	715,110	Mpls. to Mouth of Missouri River
1928	21,632	Mpls. to Mouth of Wisconsin River
1929	1,390,262	Mpls. to Mouth of Ohio River
1930	1,395,855	Mpls. to Mouth of Ohio River
1935	188,613	St. Paul District
1940	1,097,971	St. Paul District
1945	1,263,993	St. Paul District

*Tonnages exclude ferry freight (cars and other) and certain cargoes-transit.

Source: Annual Report of the Chief of Engineers, U.S. Army, Part 2 "Commercial Statistics", Table 7, by selected year.

In more recent years, data are available for the St. Paul District. Table 23 shows the movement of tonnages through the St. Paul District for the years from 1962 through 1971.

Table 23. River Shipment from 1962 Through 1971

Year	Total Traffic St. Paul District*
1962	8,168,594
1963	9,266,361
1964	9,621,336
1965	9,205,538
1966	11,346,457
1967	11,618,849
1968	10,736,350
1969	12,647,428
1970	15,423,713
1971	15,423,713
1972**	16,361,174

* Comparative Statement of Barge Traffic on Mississippi River and Tributaries in St. Paul District, U. S. Army Engineer District, St. Paul, Minnesota

** Estimated

When this table is compared with the previous one, the growth of shipping on the Upper Mississippi becomes readily apparent. Thus, the total traffic for the St. Paul District in 1962 was about six times the

traffic in 1945, which was a war year. In fact, traffic in the St. Paul District for 1962 was more than five times greater than all of the traffic on the Upper Mississippi between Minneapolis and the Mouth of the Ohio River in 1930. This was due to a large degree to grain shipments from the District and to an increase in receipts of coal.

In 1928 data were collected on receipts and shipment for the river segment from Minneapolis to the mouth of the Wisconsin River. This approximates the navigable segment of the Upper Mississippi within the St. Paul District, and the data for this segment can be equated with data for the St. Paul District with little difficulty. In that year, 21,600 tons were received and shipped. By 1940, tonnages handled reached 1,000,000 tons annually, when the lock and dam system and the nine-foot channel were virtually complete. Tonnages reached 2,000,000 by 1946, and 3,000,000 by 1953. By 1962 over 8,000,000 tons were shipped and received in the St. Paul District. In the decade between 1962 and 1972 this had doubled to 16,000,000 tons.

Table 24 shows the number of trips made on the Mississippi between Minneapolis and the mouth of the Missouri River in 1971.

Table 24. River Trips in 1971

Transportation Mode	Upbound	Downbound
Self-Propelled		
Passenger and dry cargo	1,900	1,875
Tanker	3	2
Towboat or Tugboat	8,433	8,419
Non-Self-Propelled		
Dry cargo	25,250	25,237
Tanker	7,312	7,311
TOTAL	42,898	42,844

Source: Waterborne Commerce of the United States Calendar Year 1971, Part 2; Department of the Army, U.S. Corps of Engineers, p. 165.

Because, as will be noted later in this section, Pool 9 contains only two commercial docks, a floating dock area for barges that serve utility companies, the pool is really both a thoroughfare for the Twin Cities and the origin of destination for small amounts of cargo. An indication of the "thoroughfare" function that Pool #3 provides for barge traffic in the study are the commercial lockages through all locks in the Northern Section that are shown in Figure 26. These also provide another indication of the recent increase in barge traffic. From 1960 to 1972 the number of lockages in the portion of the River between

Lock and Dam 2 and Lock and Dam 10 increased by about 600, the increase that was also present in Pool #3.

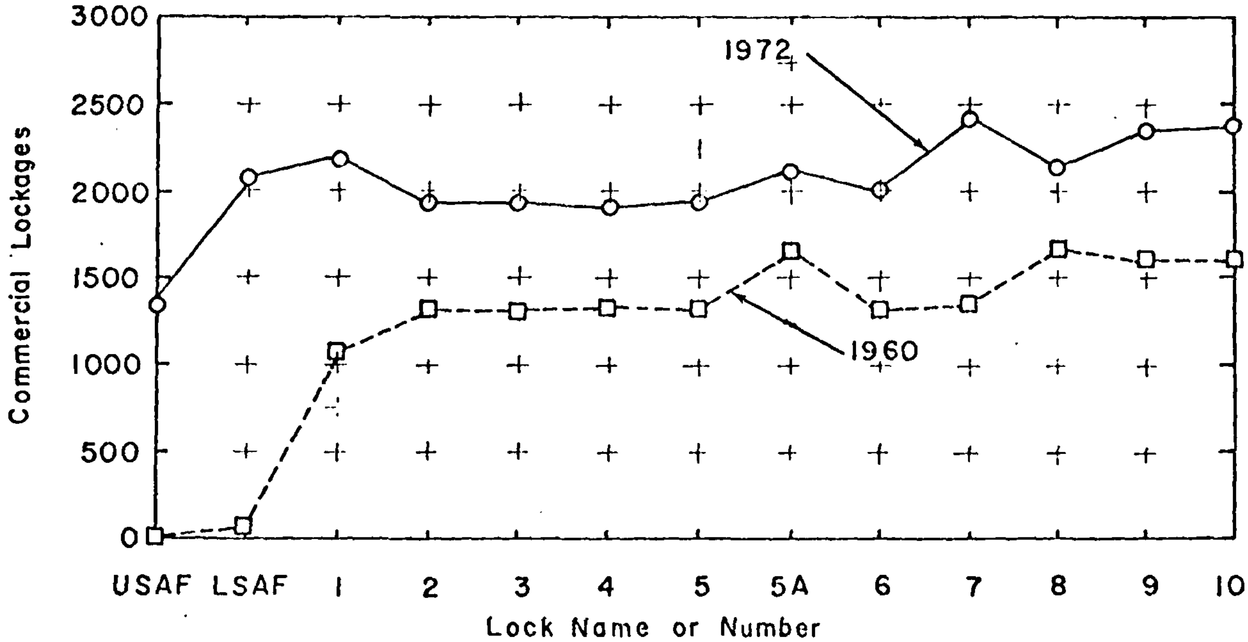


Figure 26. Commercial Lockages in Upper Mississippi River in 1960 and 1972

Source: St. Paul District of the U.S. Army Corps of Engineers, Annual Lockage Data, 1960 and 1972

The shipping season for most of the Mississippi River within the St. Paul District is approximately eight months, from mid-April to mid-December should be viewed within the context of the system as a whole including the Mississippi, Ohio, Missouri and other tributary rivers. In 1964 a detailed analysis of origin-destination waterborne

commerce traffic patterns showed that the average miles per ton on the upper Mississippi River Waterway system ranged from 700 to 800 miles. This indicates that the great bulk of shipments and receipts have origins or destinations outside the St. Paul District. Each pool then in addition to its own shipments and receipts contributes to the economic benefits enjoyed by the system as a whole. Thus, any measure of the economic benefits of the river commerce on an individual pool must include the benefits that it contributes as a necessary link in the upper Mississippi system.

Land Use

There is a multiplicity of diverse land-use within a fifty mile radius of Pool #3. The major population centers of the Pool #3 region are shown in Table 25, and distribution of people in Table 26. The agricultural land use in the Pool #3 area is shown for the three bordering counties on the pool; Pierce County, Wisconsin; Dakota County, Minnesota; and Goodhue County, Minnesota. The breakdown is shown in Table 27, and the values of the products are shown in Table 28. The pattern of Agricultural Product Diversity is seen in Table 29.

The employment patterns for the three counties are seen in Table 30, while the types and sizes of manufacturing in the three county area are shown in Table 31, along with population density of area in Figure 27.

Large scale land-use and projected uses into the year 2020 AD have been prepared by the State of Minnesota (Minnesota, 1971), and by the

Table 25. Major Population Centers in the Region

City	1970 Population	Location from Plant
Menomonie, Wisconsin	11,275	39 miles ENE
Red Wing, Minnesota	10,441	6.5 miles SE
Rochester, Minnesota	53,766	42 miles S
Owatonna, Minnesota	15,341	46 miles SW
Faribault, Minnesota	16,595	39 miles SW
Northfield, Minnesota	10,235	28 miles WSW
Hastings, Minnesota	12,195	13 miles NW
South St. Paul, Minnesota	25,016	26 miles NW
Minneapolis, Minnesota	434,400	40 miles NW
St. Paul, Minnesota	309,980	33 miles NW
Twin Cities Suburbs		
Bloomington	81,970	
Brooklyn Center	35,173	
Crystal	30,925	
Edina	44,046	
Minnetonka	36,776	
Richfield	47,231	
Roseville	34,518	
St. Louis Park	48,883	
Coon Rapids, Minnesota	30,505	50 miles NW
White Bear Lake, Minnesota	23,313	38 miles NNW

Table 26. Population Distribution in the Region

Annulus (miles)	Number of People 1970 Census	1990 Estimate	Average 1970 Density (No./square mile)
0-1	86	111	27.4
1-2	288	373	30.6
2-3	280	363	17.8
3-4	1,016	1,318	46.2
4-5	1,597	2,082	56.5
5-10	16,134	20,862	68.5
10-20	49,513	64,021	52.5
20-30	177,026	228,896	112.7
30-40	1,005,963	1,300,712	457.4
40-50	583,091	753,935	207.8
0-5	3,267	4,247	41.6
5-50	1,831,727	2,368,426	235.6
0-50	1,834,994	2,372,673	233.6

Table 27. Agricultural Land Use Near the Plant

County	Area (sq. miles)	Number of farms	Average Acreage	Area of Farms (sq. miles)	Percent of Total
Goodhue	753	1834	212	607	80.6
Dakota	576	980	250	383	66.5
Pierce	590	1649	188	483	81.9

Table 28. Market Value of All Agricultural Products Sold in 1968 (Minnesota) and 1969 (Wisconsin)

Unit	Total Value $1000's	Crops including Nursery & Hay $1000's	%	Livestock, Poultry, & Related Products $1000's	%
Goodhue Co.	33,839	6,832	20.2	27,007	79.8
Dakota Co.	19,179	6,660	34.7	12,519	65.3
Pierce Co.	21,208	1,927	9.1	19,281	90.9
State of Minnesota	1,864,931	586,406	31.4	1,278,525	68.6
Wisconsin	1,455,477	195,838	13.7	1,255,639	86.3

Table 29. Acres of Principal Field Crops Harvested and Population of Major Types of Livestock and Poultry in the Area of the Plant, in 1970

Field Crops	Goodhue Co.	Dakota Co.	Pierce Co.
Corn			
Grain	78,900	55,100	36,900
Silage	13,200	8,200	10,800
Oats	45,400	30,100	38,200
Barley	2,500	500	1,050
Wheat	3,000	4,800	750
Soybeans	51,200	34,100	4,400
Hay	59,300	28,600	57,300
Total acreage	254,400	161,400	149,400
% of farm acreage	65.5	65.8	48.3
Livestock and Poultry			
Cattle	84,000	45,400	76,000
Hogs	49,100	36,400	32,000
Sheep	11,200	2,900	3,900
Chickens	93,000	100,000	121,000

Table 30. Employment Patterns for the Three Counties in the General Area of Pool 3

Type	Goodhue Co. No.	Goodhue Co. %	Dakota Co. No.	Dakota Co. %	Pierce Co. No.	Pierce Co. %
Agriculture	2139	21.0	1352	5.9	2925	46.6
Mining	28	0.3	76	0.3	9	0.1
Construction	323	3.2	1279	5.6	139	2.2
Manufacturing	3601	35.4	8380	36.7	535	8.5
Services	4083	40.1	11741	51.5	2680	42.6
Transportation & Utilities	456	4.5	933	4.1	270	4.3
Wholesale Trade	295	2.9	1646	7.2	163	2.6
Retail Trade	1816	17.8	5638	24.7	1349	21.4
Other	1516	14.9	3524	15.5	898	14.3
Total	10174		22828		6288	

Table 31. Types and Sizes of Manufacturers in the Three-County Area Near Pool 3

Types and Sizes of Manufacturers in the Three-County Area Near the Plant [5]

Type	Goodhue County				Dakota County				Pierce County			
	No. of Plants	Employees <20	Employees 20-100	Employees >100	No. of Plants	Employees <20	Employees 20-100	Employees >100	No. of Pl[illegible]	Employees [illegible]	Employees [illegible]	Employees [illegible]
Food & kindred products	13	5	8		20	7	9	4[a]	6	4	2	
Apparel & other textile products	1			1								
Lumber & wood products	3	2		1								
Furniture & fixtures	4		1	3								
Paper & applied products					3	1		2[a]				
Printing & publishing	9	7	2		10	7	3					
Chemicals & allied products					6	4	2					
Petroleum & coal products					3	1	1	1[a]				
Rubber & plastic products	4	2	2		5	2	3		1			1
Leather & leather products	3		1	2[a]								
Stone, clay & glass products					8	6	1	1				
Fabricated metal products					11	7	3	1				
Machinery, except electrical					12	7	3	2				
Electrical equipt. & supplies	3	2		1								
Transportation equipment					5	3	1	1				
Misc. mfg. industries[b]					2		1	1				
Total	40	18	14	8	85	45	27	13	7	4	2	1

[a] One plant with >500 employees.
[b] Toys, sporting goods and athletic goods.

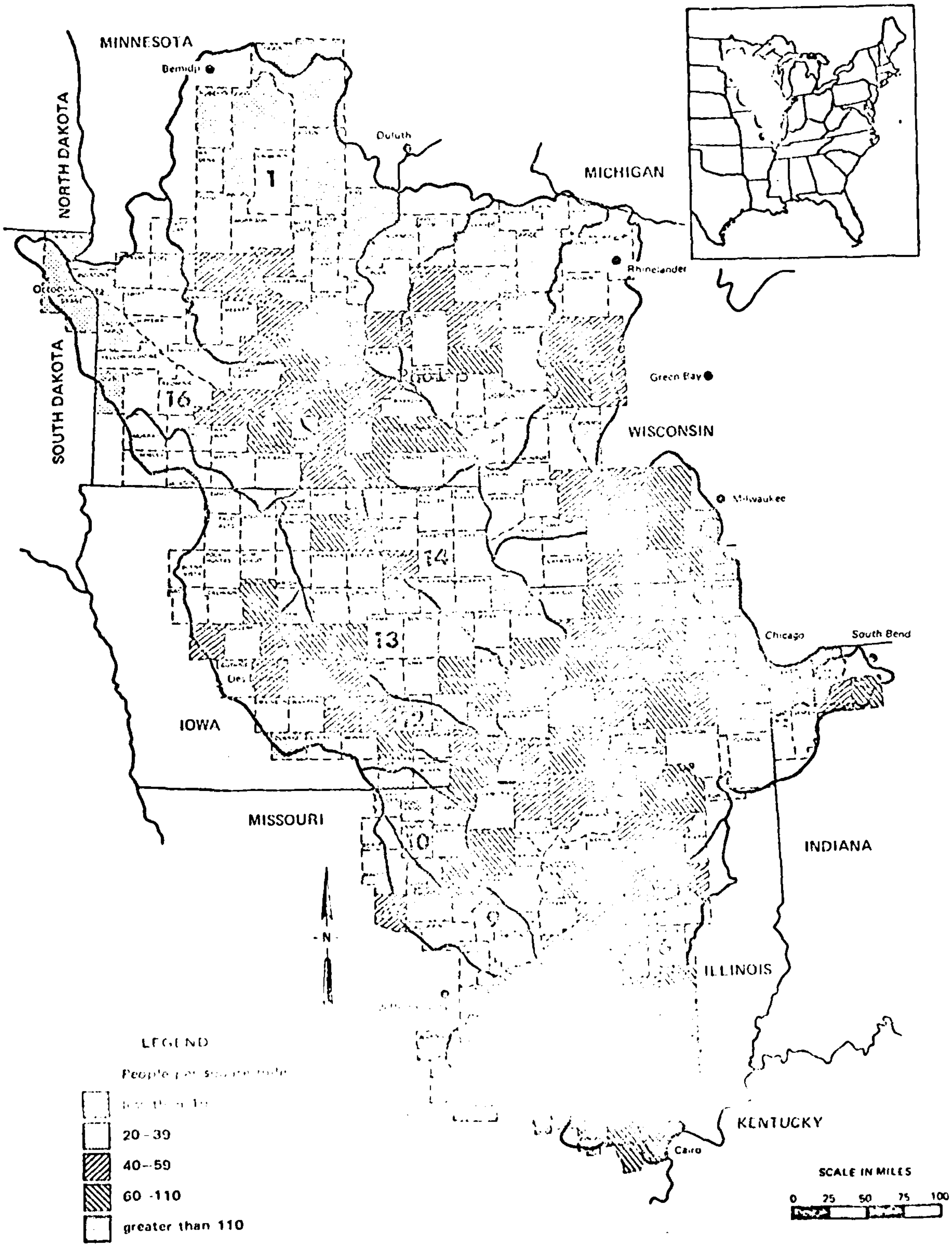


Figure 27. 1960 Population Density by Counties (Modified from UMRCBS, 1970)

upper Mississippi River Comprehensive Basin Study (UMRCBS, 1970). Plans covering the identification and management of the Minnesota groundwater charging areas for aquifers are also in motion (Minnesota, 1973).

Air Quality

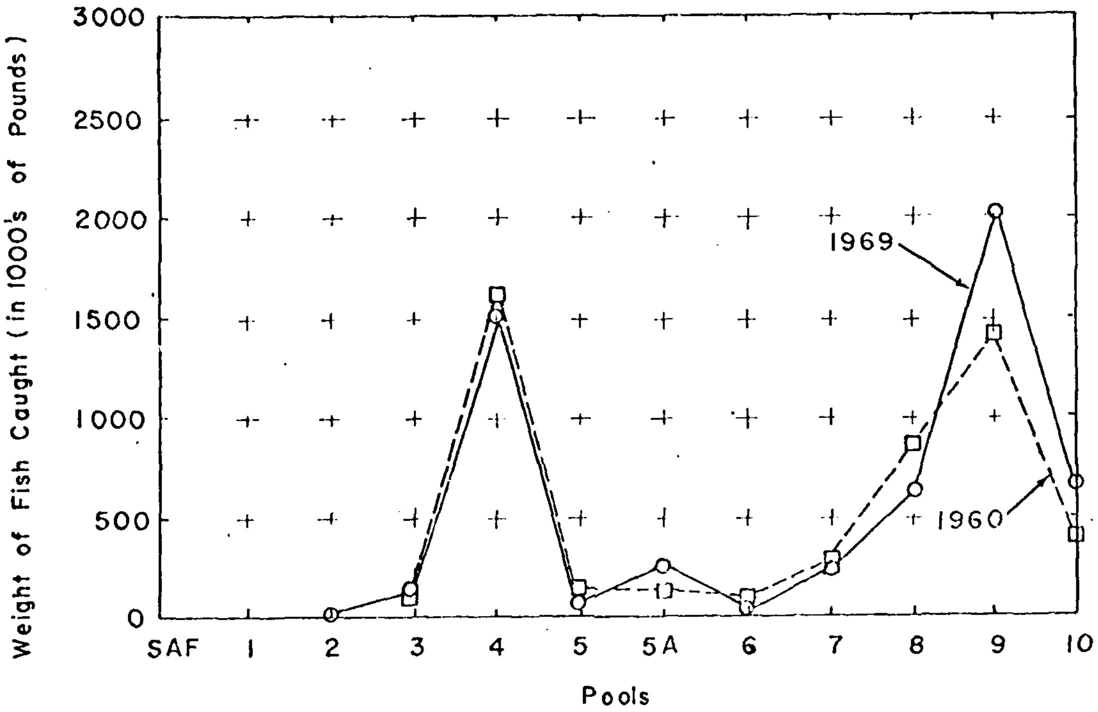
The air quality of the Twin Cities is generally satisfactory to good according to MPCA standards. Automobile emissions, and fossil fueled power plants, and the refineries in and near Pine Bend, Minnesota, are occasionally trapped by thermal inversions. Though the pool is in a relative straight line with the Twin Cities and the downwind prevailing winds, there is apparently no "rain-shadow" as is becoming more noticeable in other major metropolitan areas. If future expansions of major air polluting heavy industries are permitted in the Twin City area, (an unlikely situation), Pool #3 could be in a future "rain-shadow" area.

<u>Commercial Fishing</u>

As population along the Northern Section of the Mississippi River increased, industrial specialization also took place. The result was the development and growth of commercial fishing along the Upper Mississippi in the last half of the nineteenth century and during the twentieth century.

Limited data are available on the extent of commercial fishing prior to 1930. However, the rise in the water level behind the newly-constructed locks and dams in the Upper Mississippi River after 1930 increased the fish habitat over that existing prior to the construction.

Data on commercial fishing in the 1960's in the pool in the study area are shown in Figure 28. In 1969 the Northern Section of the Upper Mississippi River produced about 5.5 million pounds of fish that were sold commercially; this was an increase of about 9 percent from the 1960 total. The commercial value of the fish caught in 1969 was about $400,000.



Source: UMRCC. Proceedings of Annual Meeting, 1962 and 1971.

Figure 28. Thousands of Pounds of Fish Caught Annually by Commercial Fishermen in Upper Mississippi River Pools in 1960 and 1969

Figure 28 shows that bulk of the commercial fishing in the pools in the study area - about 4.8 million pounds of fish and 86 percent of the total - occurred in Pools 4, 8, 9, and 10. Pool 9 is the major contributor, with 2 million pounds in 1969. Pool 5A contributed 239,000

pounds during that year. Figure 28 also shows that little change in the weight of fish caught in each pool occurred from 1960 to 1969. Pool 9 registered the largest increase during the period from 1960 to 1969, an increase of 600,000 pounds of fish caught. Pool #3 contributes little to commercial fishing.

Tables 32 and 33 indicate the extent and species composition of the commercial fishery in Pool #3. The commercial fishery is in decline due to prices on the open market rather than due to water quality deterioration. As food prices rise, the commercial fishing in and near Pool #3 should increase. There is a tendency not to fish the waters adjacent to Lock and Dam #2 in that the detritus from the Twin Cities Sanitary District (MSSD), is thought to "taint" the flavor of sought for fish.

Table 32. Total Catch in Pounds by Commercial Fishermen in Pools Near the Pool 3 for 1964 through 1971

Year	Pool #3	Pool #4	Pool #4A*
1964	1,736	87,552	19,334
1965	1,180	45,023	3,160
1966	20,577	48,015	14,977
1967	46,330	58,699	8,809
1968	45,172	34,605	28,154
1969	26,051	25,002	36,405
1970	26,301	55,164	53,694
1971	27,837	27,343	14,860

* Lake Pepin only

Table 33. Distribution by Species of the Weight of Fish Caught by Commercial Fishermen in Pools 3, 4, and 4A of the Mississippi River During 1971

Species	Pool #3	Pool #4	Pool #4A[b]
Carp	36.8%	73.9%	52.6%
Buffalo	62.0%	7.9%	18.7%
Sheepshead	0.2%	4.2%	3.4%
Catfish	0.5%	12.7%	24.7%
Other[a]	0.5%	1.3%	0.6%

[a] Bullheads, suckers, quillback, mooneyes, goldeyes, garfish, and bowfins.
[b] Lake Pepin only

Recreational Activity

In additon to the industrial activity described above, the Northern Section of the Upper Mississippi River has provided innumerable recreational opportunities for the entire region it serves. Even prior to Congressional authorization of the 4-1/2-foot channel in 1878 - the first comprehensive project on the Upper Mississippi, from the mouth of the Ohio River to St. Paul - settlers used the river extensively. The Upper Mississippi provided settlers the opportunity to boat, fish, hunt, and sightsee. However, the need for these settlers to carve out an existence in the Minnesota wilderness of the early nineteenth century meant that recreational uses of the upper River were few. Thus, boating was not for recreational purposes; it was essential for the settlers' continuing existence to move people and supplies to where they were needed. Similarly hunting and fishing were not for sport; they provided the food needed to feed the settlers' families; surplus fish or game were sold or traded for other necessities required for daily living.

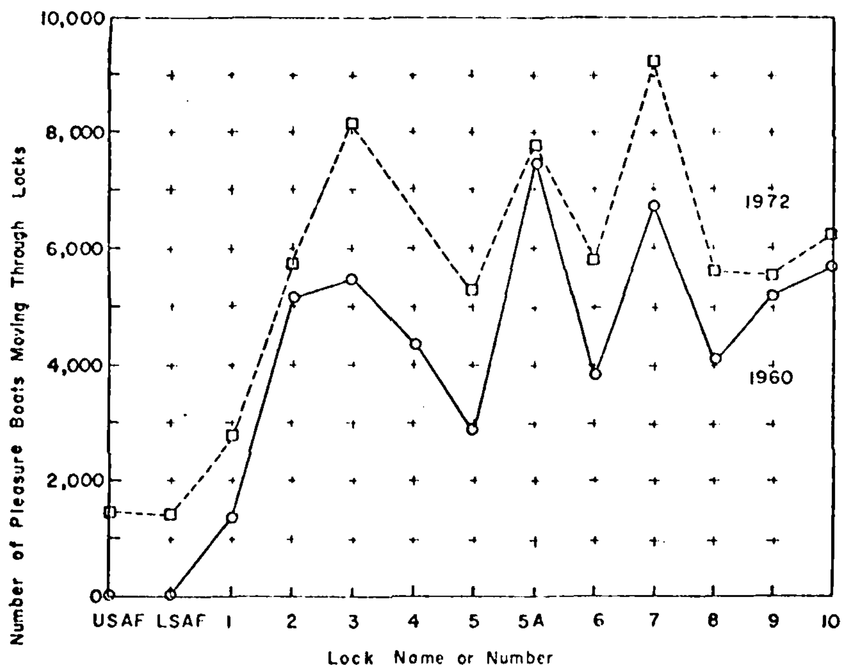
As the twentieth century dawned, leisure time accompanying the settler's higher standard of living led to recreational uses of the Upper Mississippi River. Segregating present-day recreational uses of the study area due to Corps' operations from those existing in 1930, prior to the nine-foot channel, presents problems. These arise because of the difficulty of isolating the increased recreational uses of the river caused by more people in the region, higher standards of living,

and increased leisure from those caused by improved navigational and other recreational opportunties.

A significant portion of the recreational activity on the Upper Mississippi is due (1) to the improved navigation opportunities for large pleasure craft on the river, and (2) to improved fish and game habitat resulting from higher water levels in the river. The potential for improved fishing and hunting is not always realized because increased industrialization along the river has polluted the river and has reduced the available hunting areas, which often more than offset the increased habitat.

Boating Activity and Related Facilities

As noted above, much of the increased boating in the study area of the river - and virtually all of it for the deeper-draft pleasure boats - is made possible by the improved navigational opportunities provided by the system of locks and dams. Figure 29 illustrates the dramatic growth in pleasure boating in the study area from 1960 to 1972. The figure shows that the number of pleasure boats moving through each lock in the study area increased by an average of about 1,500 boats during the twelve-year period. It can be seen that the number of pleasure boats moving through Lock #3 increased considerably above the average for the District during this period. This sharp increase is largely due to the existence of the marina and yacht harbor known as Kings' Cove where a large number of the larger boats (many owned by Twin City residents) are kept. The yachts conveniently



Source: St. Paul District of the U. S. Army Corps of Engineers, Annual Lockage Data, 1960 and 1972.

Figure 29. Pleasure Boats Moving Through Upper Mississippi River Locks in 1960 and 1972

docked at Hastings, Minnesota lock through Lock #3 to utilize the extensive pool of Lake Pepin.

Although no Federal or State parks border Pool #3 a variety of other facilities have developed on the river mainly to serve the hunters and fishermen. These are seen in Table 34 including boat access sites and landings, as well as picnic and camping sites. The major portion of visitation to the pool is accommodated by various Federal and non-Federal agencies and private interests. Most of the sites have been constructed to provide water-access for on-water type activities and, in most instances, the provision of facilties for other activities is incidental. One site is accesible only by water and one has no access to water.

Of the 8 public-use sites 4 have been developed on Corps of Engineers lands, 3 on City or Village owned lands, and 1 on State of Minnesota land. Extent of development and participation by the various contributing agencies is discussed in the following paragraphs. One site appears under two agency headings where joint development took place. Available facilities and features are listed in Table 34.

A total of 192 parking spaces is indicated as available at the 8 sites, for both car and trailer parking. Since the principal use of most of the sites is for water access and since parking facilities generally are located adjacent to or near the boat launching areas it can be assumed that most of the spaces were intended for parking of cars and trailers. Only one site has semi-permanent surfaces (blacktop)

Table 34. Major Existing Public-Use Facilities in Pool 3

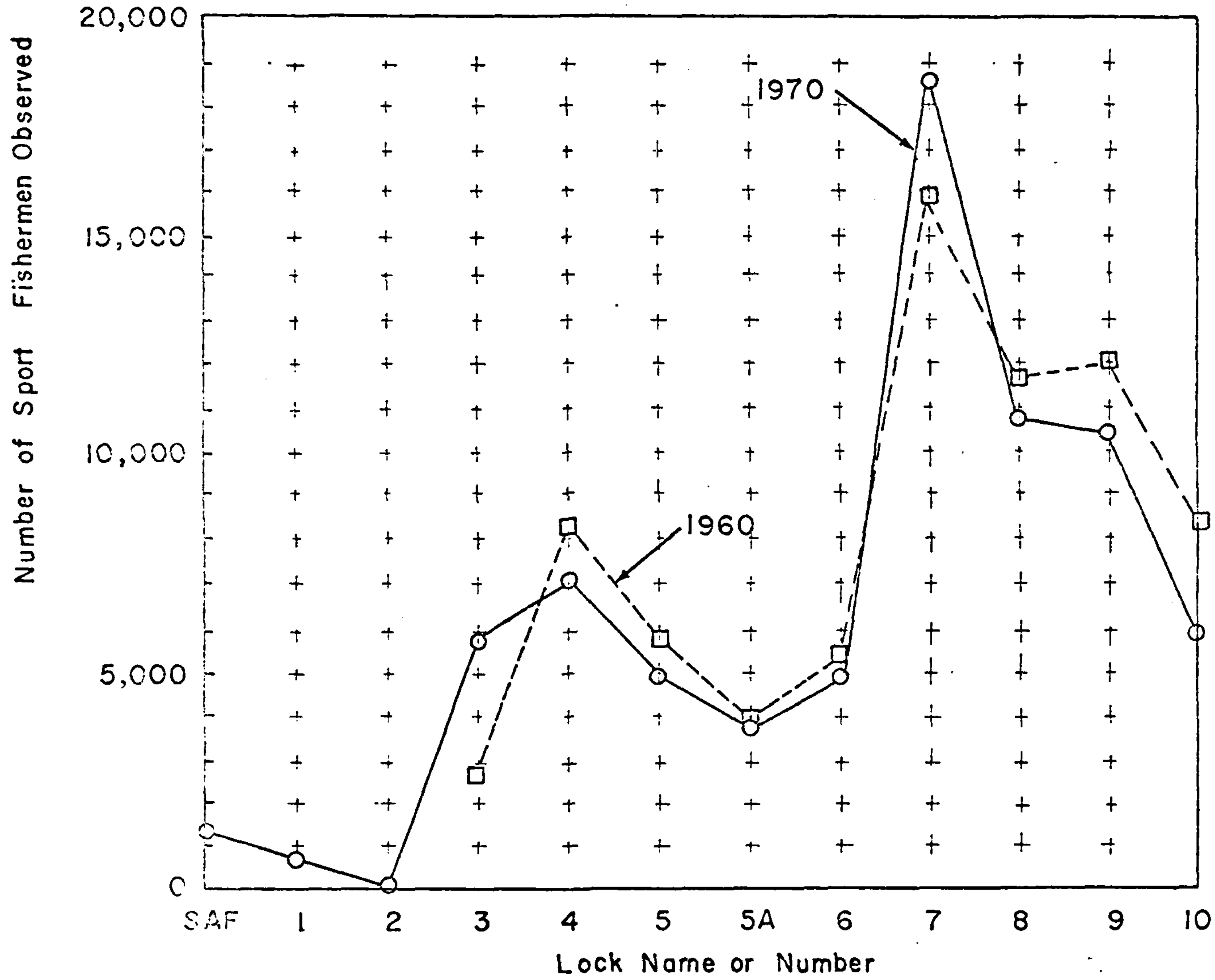
Site	River mile	Bank	Facilities developed by	Managed by	Land-owner	Ramp Width	Ramp Surface	Parking Spaces	Parking Surface	Other facilities or remarks
On Corps of Engineers Lands										
Prescott Island	811.7		Primitive	Corps of Engineers	Corps of Engineers	Beaching area				Accessible by boat only
North Lake Access	804.5	R	Minnesota Dept. of Conservation	Minnesota Dept. of Conservation	Corps of Engineers	20 feet	Gravel	60	Part gravel	Used primarily for hunting and fishing
Sturgeon Lake Access	799.0	R	Corps of Engineers & Minn. Dept. of Conservation	Corps of Engineers	Corps of Engineers	16 feet	Concrete	30	Gravel	Metal dock; guardposts and fenced
Commissary Point camp and picnic grounds	797.4	R	Corps of Engineers	Corps of Engineers	Corps of Engineers	None		10	Natural ground	Tables; fireplaces; pit toilets; well w/pump; camping on natural ground
On Non-Federal Lands										
Hastings Small-Boat Harbor (constructed by Corps of Engineers)	813.[illegible]	R	City of Hastings	Concession	Hastings	16 feet	Concrete	10	Natural surface	Sixty out of seventy parking spaces are intended primarily for patrons of harbor-furnished services
Prescott Landing (public)	811.[illegible]	L	City of Prescott	City	City	10 feet	Blacktop	30	Gravel	
Gores-Vermillion River Access	80[illegible]	R	Minnesota Dept. of Conservation	Minnesota Dept. of Conservation	State of Minnesota	20 feet	Gravel	40	Natural grassy surface	Used primarily for hunting and fishing
Diamond Bluff Landing (public)	800.[illegible]	L	U.S. Fish & Wildlife & Leo Swenson	Village of Diamond Bluff	Village	Natural sand beach		12	Blacktop	Fifty-foot platted street to beach. Parking area is near railroad

on a parking area which provides for about 12 cars. Parking areas at all other sites have nonpermanent surfacing which requires considerable seasonal maintence. In addition to the designated parking spaces available, contiguous areas of natural ground at most sites can provide supplemental parking when weather is favorable and pool level conditions permit.

Sport Fishing and Hunting

Precise measures of the number of sport fishermen using a specific pool are not available. Although creel census data are available for Pools 4, 5, and 7 in the study area, comparable data do not exist for the majority of the pools. Probably the best data available are the number of sport fishermen observed annually by attendants at lock and dam sites. Attendants to each lock and dam observe the river pool areas above and below their site at 3:00 p.m. each day and record the number of sport fishermen seen; the annual data are simply a sum of these daily estimates.

The number of sport fishermen observed by attendants at each lock and dam in the study area are shown in Figure 30 for the years 1960 and 1970. There has been little change during the ten-year period of the number of sport fishermen observed. Because fish tend to seek water with a high concentration of dissolved oxygen and the dams tend to aerate the water, the bulk of the sport fishermen tabulated in Figure 30 are probably in the pool downstream from the lock and dam cited on the horizontal axis of the figure. The figure shows that in



Source: UMRCC, Proceedings of Annual Meeting, 1962 and 1971.

Figure 30. Number of Sport Fishermen Observed Annually by Attendants from Lock and Dam Sites on the Upper Mississippi River in 1960 and 1970

1970 Pool #3, below Lock and Dam 2 had the second highest number of sport fishermen in the District. The largest number of sport fishermen in any pool of the St. Paul District were observed from Lock and Dam #7.

Sport hunting of waterfowl along the Mississippi River study area is large. However, no statistics are available that measure this activity.

Sightseeing and Picnicking

Studies in general indicate that a body of water is often essential for most recreation activities. People want this water not only to boat on or to swim in, but also simply to look at, picnic beside, and walk along. The study area of the Upper Mississippi has served this purpose for settlers for two centuries. Again, because precise data are lacking, it is generally difficult to isolate the effect of Corps' operations of recreational activities such as sightseeing, picnicking, and hiking. To assist sightseers, the Corps of Engineers operates eight overlooks at locks and dams in the study area. In addition, a variety of parks exist along the river that are available for sightseeing and other recreational activities.

Cultural Considerations

A number of archaeological, historical, and contemporary sites exist in the study area. Several sites in Pool #3 are known to have been affected by operations of the Corps of Engineers. These are discussed in Section 3.

3. ENVIRONMENTAL IMPACT OF THE PROJECT

INTRODUCTION

The major changes brought about by this project of the Corps of Engineers are:

1. Construction of dams to establish relatively stable water levels for safe navigation during the full shipping season.
2. Construction of locks to permit passage of commercial and private watercraft between pools formed by the dams.
3. A nine-foot minimum depth navigation channel.
4. The raising of the water level in the pool, resulting in the flooding of haymarshes, some farms, enlarging Sturgeon Lake, the creation of North Lake, and the inundation of the wing dams and riprap bank protection constructed earlier.

Some of overall changes in the appearance of the river valley are due primarily to urbanization in the growth of Hastings, Minnesota and Prescott, Wisconsin. A share of the urbanization incurred changes can be borne by Red Wing and the Twin Cities of Minnesota. This pool is a short distance upstream of Red Wing, and directly in the path of early attempts at navigation to St. Paul/Minneapolis and points beyond.

It is proving difficult to isolate the effects of the engineering changes brought about by the Corps in its construction and maintenance activities.

Much of the modification of riverine flora and fauna are tied in with the hunting, fishing and pollution brought about by increasing populations of people as they impinged upon the habitats formerly used entirely by wildlife and a small population of Indians in the area.

Identification of Impacts

The four changes cited in the introduction of this impact section, have led to specific impacts in the pool area. The impacts can be divided into those which result from: 1) Construction of Locks and Dams; 2) Operation of the Locks and Dams, and emergency operations during times of flood; 3) Maintenance activities in keeping the minimum nine-foot channel clear of hazards and/or obstructions. The impacts can also be thought of in terms of short-term or long-term effects, and whether the impacts are felt by the natural environment or the human environment or both.

With increasing human population density throughout the Pool #3 section of the river, recent activities by the Corps in operational and maintenance work, are felt more sharply and more immediately. The increase in commercial and recreational watercraft movements in recent years has also brought quicker notice of impacts, as well as creating impacts of their own.

NATURAL SYSTEMS

Historical Background

Early impact upon what is now Pool #3, from activities of the Corps

can be seen in Figure 31, an aerial photograph taken in 1927. The bank on the right side of the photograph is in Wisconsin. The wing dams are readily visible, and their effect upon the direction and velocity of the Mississippi River is seen as they retard the current sufficiently to accelerate silt deposition on the downstream sites. The extensive delta visible in this photograph is still a troublespot for the Corps in its continuing dredge program for the nine-foot channel. The dams also acted as a substrate for the anchoring of riverine successional growth such as Willows, Grasses, Sedges, Poplars, and other biota which would be found on naturally occurring new islands in the river channel. The pre-project impacts (prior to early 1930's), can be estimated further in considering what activities were present on the river in the earlier settlement days of the white man. During the 1820's, the Corps was removing snags, logs, sandbars, shoals, and wrecks. The primary impacts would be momentary increases in turbidity and the effects brought about by the disposition of spoils, wrecks, and other detritus. These would all be of small size and short-term effectivity. Secondary impacts might either be an increase in species diversity, by distributing the immediate populations due to activities, or a decrease in diversity by the destruction of a habitat. In either case, it is now indeterminate.

With the construction of the 4-1/2 foot channel in the late 1880-1910 period, the construction of wing dams, riprapping shorelines, and continued channel maintenance, stronger effects were noted.

Figure 31. Aerial Photo of a Portion of Pool Three Taken in 1927 Prior to Nine-Foot Channel Project

Dredging the 4.5-foot and later the 6-foot channel brought about the first dredge spoils problems, in that deposition was now a steady and increasing problem. The large "S" curve near the site of the soon-to-be Lock and Dam No. 3, was stabilized. The effects of the silt loads of the Trimbelle River of Wisconsin, the Cannon add Vermillion Rivers of Minnesota were to create deltas into the main stem of the Mississippi River. The result was that the "S" pattern was consistently shifting back and forth across the channel with very little riverbed stability. This would have meant few substrates for macroinvertebrates. The shifting sands at the river bottom would have "scoured" organisms such as the burrowing mayflies (Hexagenia sp.) precluding their survival. The building of the wing-dams and the riprapping of the most tenuous shore areas, provided additional substrates for the invertebrate biota, as well as providing spawning surfaces for fish. The "barriers" of the wing-dams also provided protection from the current for fish within the main stem or channel.

Two of the old "ox-bows" created by shifting of the main river channel can be seen in Figure 32, an aerial photograph taken April 5, 1973. The view is of Lock and Dam No. 3 with the roller gates in an open-flow position. The two ox-bows are in the lower right of the figure, and are on private property. They are not a part of the "channel" except during flood periods. Navigation with small boats into the ox-bows cannot be accomplished from the mainstream. The

Figure 32. Aerial View of Lock and Dam 3 from Wisconsin. Roller gates are in open-flow configuration. Note old channel ox-bows in lower right corner.

waters of the ox-bows have been isolated from the main channel, which leaves them for land-succession as ponds. The deposition of silt loads during high waters of spring floods will accelerate the filling of the ox-bows. Currently, they are waterfowl habitat, and some rearing of carp is carried out. The stabilization and isolation was partially pre-project, and partially carried out by spot-dike construction during the building of Lock and Dam 3.

Secondary impacts of the pre-project work by the Corps would include the stabilization of channels bringing about new niches and thereby new populations of invertebrates. The "slowing" of the river-edge by wing-dams would decrease the extent of and the numbers of rheophilic organisms. With the change in habitat, obviously the ecosystem was changed, but in this instance, perhaps for the better. There was increased stability in the substrate, which should have increased the biotic stability. Whether the species diversity increased or decreased is debatable, and is not now ascertainable.

Nine-Foot Navigation Channel Project

Those impacts which can be attributed to the current nine-foot navigational channel construction and maintenance are similar to those created by the 4.5- and 6-foot channel projects, see Tables 35 and 36.

Table 35. Impacts on Natural Systems Caused by Operations of Corps Facilities, 1938 to Present Time*

Project Feature (activity/structure)	Primary Impacts within/on Pool 3	Secondary Impacts within/on Pool 3
Lock #3 operations	None noticeable	None noticeable
Dam #3 operations	Modifies current velocities/volumes and turbulence	Aeration and upgraded water quality and better gamefish habitat
During navigation season	Stilled area downstream of lock	Less current velocity for better panfishing
During floods	Large "lake" created with slower currents	Refuge areas for fish to escape velocities
During winter	Creates open water in tailwaters for aeration caused by turbulence	Aeration helps increase DO in water for all aerobic organics

*Impacts caused by dredging operations discussed in Table 36.

Table 36. Impacts on Natural Systems from Corps Maintenance Activities, 1938 to Present

Project Feature (activity)	Primary Impacts within/on Pool 3	Secondary Impacts within/on Pool 3
Navigation channel dredging operations	Increased turbidity, spoil disposal	Loss of some benthic substrate and organisms, disruption of ecosystem in microhabitats, makes desert islands, makes beaches, may cut off backwaters, cuts and chutes. Re-erosion to river channel.
Snag removal	Unsightly, if dumped in view of public	Small amount of substrate [illegible] for [illegible] inverts.
Barge fleeting area (landward of Prescott Island, near Prescott)	Corps impact is from dredging, see above	Some small area of substrate lost; not very significant pool-wise.

Impacts Caused by Construction of Lock and Dam 3

The Vermillion River was rerouted from its original juncture with the Mississippi River to a point about 1.5 miles downstream, with the dam constructed at the former juncture.

A new navigation channel was cut straightening out two curves for a nautical distance of about two miles into what is now Pool 4. This separated the channel flow of the main stem from the navigation channel. It also changed the flow of main river traffic to the north side of Diamond Island (Mile 795). Though these are considerations which rightly belong in the Pool 4 report, the net effect of the two immediate impacts was to cause the sediment load of the Vermillion River to be deposited in the former river channel south of Diamond Island. In order to redirect this water around the north side of the island, a semi-closing type of wing-dam was built at UM 795.5 which is now under water, covered by sand for half of its former length, and which is causing difficult recreational traffic situations caused by shoals. The impact upon fishing in this area is unknown, in that no pre-project fish information seems fully reliable. The area is currently excellent for gamefish, and is used fairly constantly by commercial fishermen when fish prices are high enough to warrant commercial fishing.

"Pickerel Lake" was isolated from the main river by the construction of the road/dike connecting the Locks with the Chicago, Milwaukee, St. Paul and Pacific Railroad tracks. This "lake" is inundated during some extreme floods, but is otherwise closed. The effect is to stagnate the water, creating a pond out of it. It is subject to winterkill caused by low DO levels with snow cover. Previously, any fish in the water body could escape during oxygen depression.

The construction of the spot-dikes (10 of them) effectively cut off water passage through the private property known as Gantenbein Bottoms. The closing of free-flowing water causes the "bottoms" to fill in at a more rapid rate because of silt deposition during periods of high water. The spot-dikes do not effectively stop all waters from passing "behind" the dam, but serve to preclude excessive washouts with resultant new channel cutting by flood level waters.

Impacts Caused by Construction of Locks to Permit Passage of Commercial and Private Watercraft Between Pools Formed by Dams

In addition to the actual construction impacts cited in the preceeding paragraphs, there was an inundation of the bottomlands to a level of 675 feet for a flat pool. The flooding of great areas of haymarshes and other very lowland marginal small farms on the Minnesota shore was an expected consequence of the dam and locks. These private low lying properties had been acquired by the Corps prior to construction of the dams in anticipation of their being flooded as the water within the pool rose to its designed level. Though some of these farms were productive, and some of the wildlife marsh-type habitat was lost, new marsh areas and increased water areas for fish productivity were generated. These consequences may be considered a trade-off of environmental habitats.

The straightening of the entering waterway around Diamond Island cited earlier, created a navigational channel adjacent to the Locks at #3 (downstream), which afforded new fish habitat and which is currently used heavily by recreational fishermen and boaters. The increased water area is a positive gain as far as fishery scientists are concerned, but the lost land area is a detriment in the eyes of terrestrial ecologists. Again, a trade-off of habitats.

The inundation of the riprapping shore protection created several problems. First, the role of shore-line protection caused by excessive navigation-created wave-action, was obverted and the shores have been eroding since 1938. Second, the current actions coupled with the movements of ice during the winter-spring seasons have further destroyed the upper portions of the bank protection structures, to a point of noneconomical repair or replacement. The remaining structures are excellent substrate for immature aquatic insects, developing forms of zooplankters, for attached forms of algae and diatom development and/or growth. Small-mouth bass (Micropterus dolomieu) have been observed for many years along the wing dams, and have been fished regularly along the now underwater bank protection as prime fishing areas. Though the original function of these riprapped areas has been lost, they are a positive impact upon the fishery. The extent of the riprapping in this pool was cited earlier as approximating 13.5 miles; therefore, there is extensive "new substrate"

now being provided by the Corps because of original construction. The inundation and subsequent damaging of the riprapping also has provided a microhabitat for small invertebrates and immature and some forage fish as a protected area from the current, and from large predators. The area is generally muddy because of the lapping action of waves rebounding between riprapping and the shore, all as a consequence of waves created by commercial and recreational watercraft, and at times from wind-generated wave action.

Impacts Caused by a Minimum Nine-Foot Channel Depth

The most obvious feature connected with channel depth and width maintenance is the effect of dredging operations. The dredge spoils deposition creates "desert islands" or damages islands already present, creates beaches for recreational boaters which in turn has detrimental impacts upon benthic organisms. If the spoils are deposited in relatively low altitude islands adjacent to the main channel, they frequently are rapidly returned to the river by wind and water erosion from normal rains, winds and seasonal floods. On some disposal sites,channels are blocked into backwater areas, side channels filled, or submerged organisms buried by the resultant slurry of water/sand/organic debris being dredged. There is an immediate but temporary increase in turbidity with resulting benthic habitat loss or damage. If a large portion of the dredged materials are organic sludges, there will be a temporary BOD increase, and secondary DO depression. The organisms already living in the dredge area will be dispersed, destroyed or at the very least, dislodged, opening them to higher rates of predation.

The actions of dredging tend to clog the respiratory surfaces of both the fish in a fishery, and the larger invertebrate prey of the fish. In spite of this, it might be less detrimental to both types of organisms, if dredge spoil materials were just returned to the center of the navigation channel in the deeper sections within reach of the dredge spoil distribution piping. In Pool 3, the Thalweg of the main channel is generally relatively barren of either invertebrates, or sedentary fish which wouldn't have the ability to escape the direct effects of the dredging activity and the dredged amounts are generally not excessive quantities at any given point.

Overall, the obvious results of the 9-foot channel construction and maintenance are:

1. Active commercial navigation within the channel;
2. A navigation channel with minimal 200' width, and 9-foot depth;
3. A new lake, North Lake, and an enlarge Sturgeon Lake;
4. A pool relatively free of navigational hazards in the navigational channel;
5. Filed dredge spoils in areas with sedimentation problems;
6. The "clear" channel created by the inundation of the wing dams constructed prior to this project; appears more "normal";
7. A larger fishery with the increased water surface of the pool.

The less obvious changes are those taking place in the biotic portion of the overall riverine and newly created lacustrine situations.

Aquatic Systems Effects

With the flooding of the pool subsequent to completion of the Lock and Dam 3, the aquatic portion of the pool was enlarged and in general benefitted to the expense of the terrestrial systems. The increased stability of the lower portions of each pool tended to stabilize the species makeup of the aquatic systems. With the enlargement of Sturgeon Lake to almost double its original status, and the creation of North Lake which is larger than Sturgeon, there was a concommitant increase in the availability of shallow water spawning sites, more accesses to the main channel and a greater practical littoral zone. The waters of North Lake are extremely shallow (0-2 meters), with more clarity, and therefore, more capability for photosynthetic activity, than either Sturgeon Lake or the stem channel. The relative uniformity of the depth of North Lake has limited the expansion of Typha/Scirpus/Sagittaria compled marsh areas. The fluctuation of the North Lake water level through the normal rise and fall of the pool depth caused by rains in varying portions of the Upper Mississippi River watershed, creates spates, or flushing of many pseudoplankters or tychoplankton into the receiving waters of the Mississippi and Sturgeon Lake. These plankters form a substantial part of the food of larval fishes in the spawning areas downstream (Miller, 1973).

The fact that a lacustrine or lake-type ecosystem is located at the lower or downstream portion of each pool has the interesting result of creating a series of lakes going south with the current of the mighty Mississippi River. The invertebrate biota, the overall composition of fish just upstream of Dam 3 indicate that it is a lake, not river for the short distance above the dam (Miller, 1972). The ongoing studies by Miller for Northern States Power and the Department of Interior, Office of Water Resources Research, has indicated that for the 1970 and 1971 calendar years, that 66 percent of the fish caught upstream of the dam by electrofishing and trap-netting were rough species, and that 34 percent were considered as game fish. During the same period in the tailwaters of the dam, 84 percent were game species, while 16 percent were rough fish or forage fish. This is normally expected phenomenon, but the distributions are directly caused by the presence and operation of the dam.

There are limited areas of mudflats caused by frequent fluctuations in water level. Looking at the Flowage Survey maps, it would be assumed the topography was of a nature that there were probably more mudflats prior to this project.

Terrestrial Systems Effects

Obviously, the statements of the preceeding paragraphs bear upon the effects on the terrestrial biota. There was extensive lumbering of the trees in the flats which ultimately became North Lake, and on the fringes of the old morphology of Sturgeon Lake. The lumbering was carried out to minimize the deleterious effects of flooding the extensive bottomland forest. The wood was commercially salable, and the employment was necessary during the depression years of the middle 1930's. There still exists very extensive stump fields in both North Lake and Sturgeon Lake. The stumps are so wide-spread that it almost totally discourages use by pleasure boats. Only locally knowledgable fishermen use both lakes, and then, sparingly, in North Lake.

Beneficial Impacts

The most obvious beneficial impact of the 9-foot channel project was the stabilization of the water levels of the various pools, especially during the mid- and late-summer dry periods. This also led to a maintained current velocity, which probably has helped the water quality during what used to be periods of stress.

The inundation of the 133 wing dams has created a widespread and reliable substrate for myriads of immature invertebrate fauna for use as a part of the fishery food webs. These wing dams and the now underwater riprapping also are fine substrates with accelerated currents for attachment of demersal eggs deposited by fish as Walleye, or Saugers. The current would have the effect of "sweeping" silt deposits from the eggs, and to carry waters with a high dissolved oxygen content into these areas which generally have a fairly high BOD caused by organic waste loads from the upstream metropolitan areas.

Detrimental Impacts

In Pool 3, the most detrimental effect easily observable, is the impact of dredge activity and dredge spoils deposition in areas which may be inimicable to organisms in the dredging area or deposition areas. A further consequence of spoils, is the cutting off of small chutes into the backwaters areas, which in turn causes stagnation of these waters with resulting loss of aerobic habitat, spawning sites, and overall productivity for the main channel.

Perhaps the most serious aspect of the problem is that it is a non-ending threat to the biota. Examination of the aerial photos of this pool taken in August of 1927, demonstrates the role played by each of the coulees as drainage concentration channels for silt. At each of the coulees, a delta had formed and then been washed downstream by the river into wing dams and the spaces between them. The steady fillingin is a grim reminder that dredging is only delaying the time of final channelization of the river. Further examination of aerial photos over the pool in subsequent years shows the steady encroachment into channel formation. This problem requires further investigation on a high priority basis and an early solution.

SOCIOECONOMIC SYSTEMS

Specific impacts of Corps' operations on the subdivisions of socioeconomic systems for Pool 3 are identified below and then discussed in detail.

Identification of Impacts

The impacts on the socioeconomic systems related to the study area of the Upper Mississippi River divide into the industrial, recreational, and cultural effects.

Industrial Impacts

The principal industrial impacts are:

1. Barge transportation on the Upper Mississippi that leads to:
   a. An increase in commercial docks on the River and attendant employment;
   b. Location of industrial plants along the River whose raw materials or products lend themselves to shipment by barge; this contributes direct employment in these plants and indirect employment in firms--
      (1) Providing goods or services as inputs to the barge-oriented plants, or
      (2) Using the outputs of these plants or raw materails for their own operations
   c. A decline in the quality and increased turbidity of water in some portions of the Upper Mississippi River because of--
      (1) Effluents produced by barge-oriented plants, and
      (2) Turbidity caused mainly by barge movements.
2. Additional employment because of the operation of Lock and Dam 3;
3. Potential increase in commercial fishing because of:
   a. Increase in DO in channel because of faster current in deeper channel, leading to increased water turbulence, and
   b. More fish habitat because of increase acreage of fish spawning areas from rising water level; this potential has not always been realized for reasons to be developed below.

To summarize, beneficial industrial impacts that result from operating and maintaining the 9-foot channel and its associated locks and dams by the Corps of Engineers are an increase in the number of industrial plants and commercial docks along the River with their associated employment, the employment in lock and dam operation, and an increase in the potential for commercial fishing. The detrimental effects are a decline in water quality caused by river barges and the related industrial plants along the River.

Recreational Impacts

The principal recreational impacts are:

1. An increase in recreational boating caused by stable, navigable water levels which leads directly to more marinas--and their accompanying employment;
2. A potential increase in sport hunting and fishing because of an increase in --
   a. Waterfowl habitat, and
   b. Fish spawning areas resulting from rising water levels
3. An increase in sightseeing visitors to the Locks and Dams.

The effects cited above are positive except for those caused by increased activity (barge traffic and industrial plants) that may hurt hunting and fishing.

Cultural Impacts

At this stage of research, few archaeological, historical, or contemporary sites of cultural significance in Pool 3 are known to have been affected by Corps' operations. They are discussed in Appendix B.

Discussion of Impacts

The industrial and recreational impacts identified above are examined in detail in the following sections.

Industrial Activities

The economic effect of the activities of the Corps of Engineers on the Mississippi River in the St. Paul District can be measured mainly in terms of three major elements. They are:

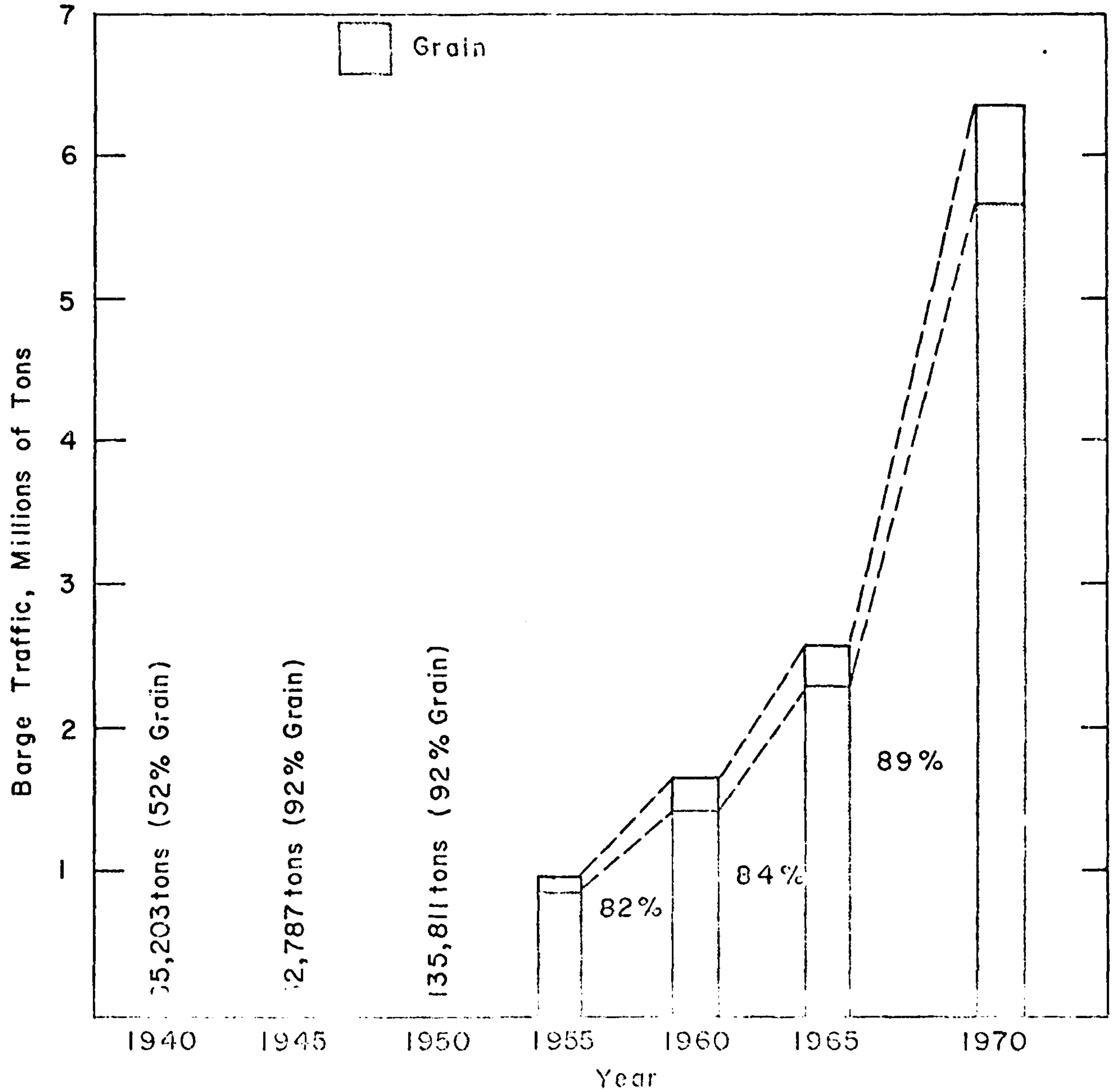
1. The channel itself with its associated locks and dams and navigational aids;
2. The installations at riverside for the transfer of cargo, storage facilities, and access;
3. The vessels using the waterway.

In these terms, the impact of the Corps' activities in Pool 3 is not as great as in some of the other pools in the Northern Section of the Upper Mississippi River.

Barge Activity. The greatest and most obvious impact of the activities of the Corps of Engineers in Pool 3 has been the modification of the transportation system caused by the growth of barge traffic. The visual evidence of the impact is seen in the physical structures (e.g., locks and dams, the two commercial docks and fleeting area on the shores and the barge tows moving along the river. However, Pool 3 has not been the origin or terminal for most of the commodities that move in barges along the Upper Mississippi River. Rather, it serves as an important water link between important commodity terminals upstream and downstream from it.

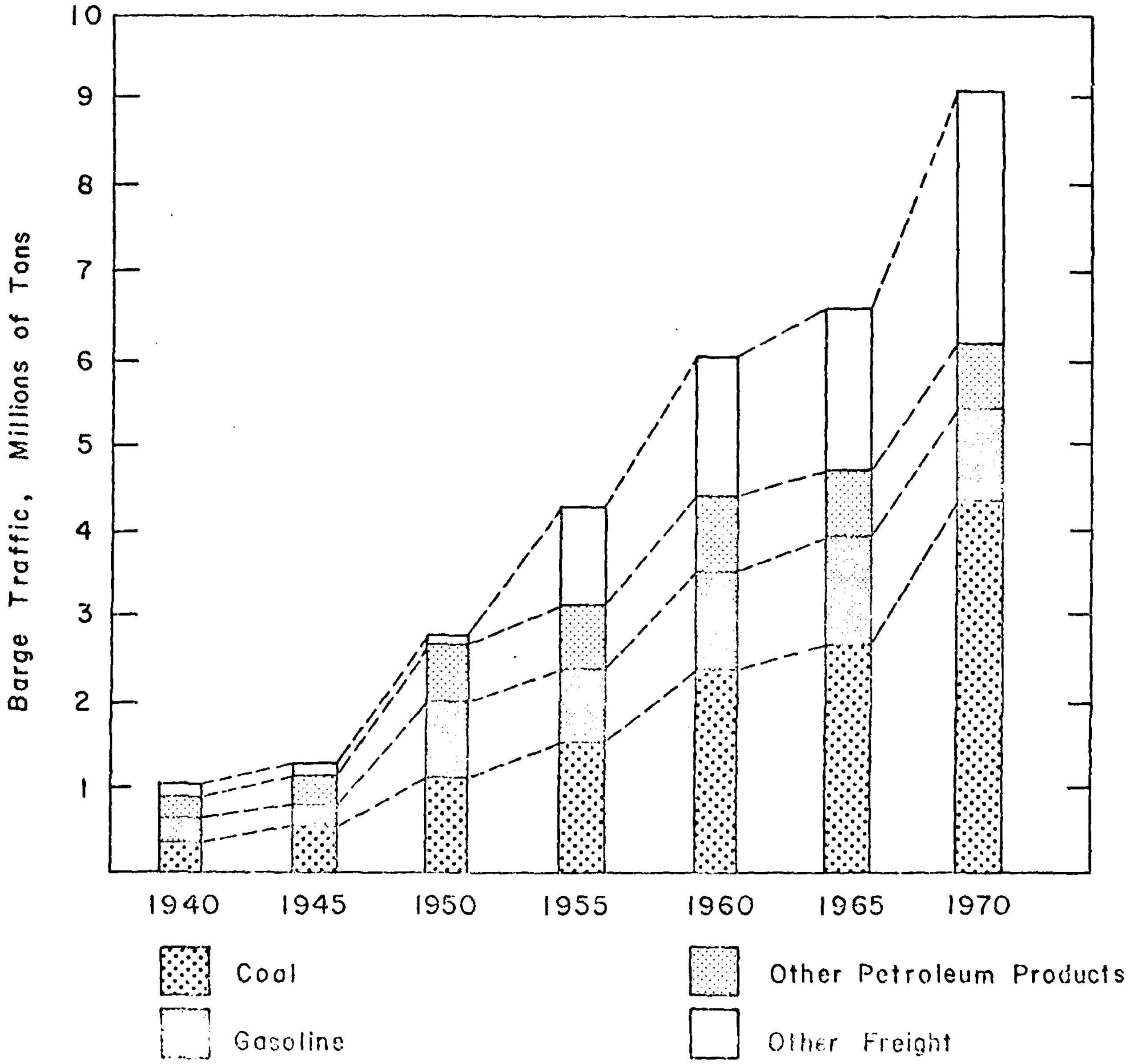
Figures 33A and 33B show graphically the growth of receipts into and shipments from the St. Paul District in the 30 years from 1940 to 1970. Commodities shown in the figures, with the exception of some miscellaneous freight and petroleum transferred at the two commercial docks, flow through the pool enroute elsewhere. Although receipts still substantially exceed shipments, the growth in shipments (89 percent grain) from the district in these three decades indicates the great impact of the river on the regional economy.

In 1970 some rough projections (based on 1964 data) were made of the growth of commerce in the St. Paul District (UMRCBS, Study Appendix J, 1970). The projections suggest that the tonnage of barge traffic moved in the Upper Mississippi River basin will about double from 1964 to 1980 and about triple from 1964 to 2000.



Source: Based on data from U.S. Army Corps of Engineers, St. Paul District, St. Paul, Minnesota

Figure 33A. Shipments Out of the St. Paul District



Source: Based on Data from U.S. Army Corps of Engineers, St. Paul District, St. Paul, Minnesota

Figure 33B. Receipts of Major Commodities--All Ports, St. Paul District

It is noteworthy that receipts into the St. Paul District have always exceeded shipments. In earlier years this imbalance was often extreme (e.g., 1953 receipts = 3,052,144 tons; shipments = 334,233 tons). Recently, however, the ratio has been around 2:1. Inasmuch as grains and soybeans constitute the preponderant tonnage of shipments, fluctuation in waterborne transport of these products can be profound because of crop conditions and storage facilities, foreign sales, and competing forms of transportation.

Data are not available on the numbers of vessels originating, terminating, or passing through the St. Paul District. However, some comparative idea of shipping activity can be gained from the following information. Vessel traffic measured in tons from Minneapolis to the mouth of the Missouri River is shown for selected years as follows:

Year	Total Vessel Traffic (tons)
1962	30,526,626
1964	34,108,482
1966	41,311,941
1968	46,174,929
1970	54,022,749
1971	52,773,097

Statistics on the numbers of vessels originating, terminating, or passing through Pool 3 are not available directly. However, some comparative idea of barge activity can be gained from studying the commercial lockages through Lock 3 and Lock 2--the locks at either end of Pool 3--which are shown in Table 37. From 1960 to 1972 commercial lockages through Lock 3 increased by 48 percent and those through Lock 2 increased by 48 percent.

Table 37. Commercial Lockages in Pool 3, 1960-1972

	Commercial Lockages	
Year	Lock 3	Lock 2
1960	1303	1302
1961	1318	1191
1962	1302	1325
1963	1468	1561
1964	1463	1561
1965	1292	1426
1966	1568	1588
1967	1499	1727
1968	1558	1530
1969	1636	1539
1970	1576	1853
1971	1860	1825
1972	1931	1929

Source: Annual Lockage Data (St. Paul, U.S. Corps of Engineers, St. Paul District, Unpublished reports)

Commercial Dock Facilities. Firms that depend heavily on the river often maintain riverside facilities. Pool 3 contains two commercial docks and terminals. One is the Great Northern Oil Company and the other is Hasting's Landing, which handles miscellaneous freight.

Behind these docks are refinery, factories, and storage facilities that are dependent upon them. Thus, the ramifications of river navigation reach deeply into the entire economy of the region surrounding Pool 3 and indeed throughout the whole Upper Mississippi region. Employment directly and indirectly connected to these industries forms a small though significant percentage of the regional work force.

From an economic point of view most of the effect of the activities of the Corps of Engineers are beneficial. Ultimately, the benefits of economic activity have to be measured in terms of providing livelihood to human beings.

Employment generated by the availability of waterborne transport to Pool 3 includes both workers directly connected with the river itself and a far larger number of those whose livelihood is less directly dependent on water shipping. In the first category is included employment by the Corps of Engineers itself, workers on docks and shoreside facilities, and those working on the vessels themselves. The second category consists of those whose livelihood is gained by either using the products brought into Pool 3 by waterborne carriers or who process goods shipped by water. Included in this category are those who supply goods and services to those directly involved with water shipping on the Upper Mississippi River.

The total employment involved either directly or indirectly with all commercial operations on the river is not known. The Corps of Engineers itself has some 150 persons who are concerned with lock and dam operations. In addition to this, the dredge "Thompson" has approximately 65 crew members. U.S. Department of Commerce data on employment on the Upper Mississippi are deficient as well. These data are collected for mid-March, a period when water traffic in the St. Paul District is almost completely inactive and seasonal lay-offs are in effect. Further, these data are aggregated in a way designed to prevent isolation and identification of particular firms. This also has the effect of preventing identification of employment or other economic activity in particular pools or even of particular waterways. However, some estimates of employment can be made. In mid-March of 1971, 8632 persons in the U.S. were employed in River and Canal Transport. This figure does not include warehousing or persons employed by firms where the SIC classification lies outside of transportation, even though they themselves may be working exclusively on the river. The same data show 556 persons in Minnesota as a whole who work in the field of water tranport. This, however, includes the Great Lakes as well as the Upper Mississippi. Some of these people are employed by private dredging firms whose existence is dependent upon the work of the Corps.

A further benefit which can be attributed to the maintenance of navigation on the Upper Mississippi is in the savings in transportation costs, particularly for bulk commodities. Estimates of these savings have been made. One of these estimates the savings over the other various least-cost alternatives of between 4.0 and 5.4 mills per ton-mile.* It is generally recognized that bulk commodities, particularly those having low value-to-weight ratios, are appropriate for barge transport. Coal, petroleum, and grain that have the these characteristics are examples of such commodities that originate, terminate, ane move through Pool 3 on river barges.

The socioeconomic impact of the physical effects of navigation cannot be measured precisely because of the inability to isolate single factors from a wide range of potential ones. Dredging and the movement of tugs and barges does increase water turbidity to which must be added pollution from barge spillage, washing and loss while loading or unloading. Yet this pollution is small relative to the load placed in the river from other sources. These impacts may have economic effects on commercial and sport fishing, which are discussed below.

Commercial Fishing. Pool 3 has a small but noteworthy commercial fishery. It is the northernmost pool in which substantial commercial fishing takes place. Compared with Pool 4, however, it is not large. Table 38 shows the catch for each year from 1960 through 1969.

The commercial catch fluctuates widely in this pool from year to year. This is probably an indication of the pool's sensitivity to environmental impacts. The proximity to Pool 2 with its frequent high levels of pollution may influence the catch in Pool 3.

In the past, the activities of the Corps of Engineers have been both beneficial and detrimental. In the 1920-1930 period, single hauls in excess of 30,000 pounds of fish were made by at least one commercial fisherman in this pool (Vic Gantenbein, personal communication, 1973). He used the then exposed wing dam as a pivot point for his nets. With the inundation of the wing dams this was no longer possible, but in compensation the raised water level created more, but less, efficient fish areas.

*Source: Upper Mississippi RIver Comprehensive Basin Study, Appendix "J", p. 90.

Table 38. Pounds of Fish Caught Annually By Commercial Fishermen in Pool 3 of the Upper Mississippi River, 1960 to 1969

Year	Commercial Fish Catch
1960	119,000
1961	104,000
1962	46,000
1963	39,000
1964	89,000
1965	Not available
1966	21,000
1967	46,000
1968	363,000
1969	129,000

Source: Proceedings of the Annual Meetings of the Upper MIssissippi River Conservation Commission, 1962-1971

Recreational Impacts

Recreational impacts may be divided into boating activities and related facilities, sport fishing and hunting, and sightseeing and picnicking.

Boating Activities and Related Facilities. For Pool 3, the best available measures of pleasure boating activity are records of pleasure boats locking through Locks 2 and 3--the locks at each end of the pool. These data, along with the total pleasure-boat lockages through these two locks, are shown in Table 39 for the years 1960 to 1972. The table shows a sharp increase in pleasure craft lo[illegible] 5500 in 1960 to about 8100 in 1972) and a small increase at Lock 2 (from about 5100 in 1960 to 5700 in 1972) during the period. The table also shows an accompanying increase in the number of pleasure boat lockages at Lock and Dam 3 (though not at 2) during this period, although the increases have not been as dramatic as for the number of pleasure boats moving thoough the lower locks.

Table 39. Measures of Boating Activity in Pool 3, 1960-1972

	Pleasure Boats Through		Pleasure Boat Lockages Through	
Year	Lock 3	Lock 2	Lock 3	Lock 2
1960	5486	5137	2760	2484
1961	5490	5536	2748	2519
1962	4501	4270	2372	2184
1963	5113	5174	2497	2412
1964	4784	5107	2488	2537
1965	4139	3308	2096	1827
1966	5379	4423	2377	2213
1967	4519	3869	2528	1981
1968	3992	4702	2385	2181
1969	3747	4189	2499	1888
1970	6641	4555	3258	1953
1971	8051	5788	3282	2359
1972	8102	5723	3252	2354

Source: Annual Lockage Data, St. Paul, U.S Corps of Engineers, St. Paul District, Unpublished reports

As mentioned in Section 2 of this report, many of the larger yachts owned by regional residents (including the Twin Cities) are docked at Conley Lake in Pool 3 from whence they pass through Lock 3 into Lake Region (Pool 4). The raised water level caused by Lock and Dam 3 have made this possible because of the deeper drafts of the large yachts.

Visitation to Pool 3

Although actual numbers of visitors to Pool 3 for recreational purposes is not precisely known, some informed estimates have been made. Data compiled in 1963 from spot checks and sample counts by the Corps of Engineers was made (St. Paul District, July 1967). Pool 3 had the third highest visitation in the St. Paul District, estimated at 20,000. Table 40 shows the visitations by recreational activity.

Table 40. Entire Pool 3 Visitation, 1963

Activity	Annual - 1963 Percent of total	Annual - 1963 Number	Peak Month (August) Percent of total	Peak Month (August) Number
Camping	16.5	33,000	15.0	9,000
Picnicking	6.8	13,600	10.6	6,360
Boating	34.3	68,600	44.3	26,580
Fishing	33.1	66,200	17.7	10,620
Water skiing	1.2	2,400	1.8	1,080
Swimming	7.3	14,600	10.6	6,360
Subtotal	99.2	198,400	100.0	60,000
Hunting	0.8	1,600	--	1,000 (Oct.)
Total annual	100.0	200,000	--	--

Restricted visitation in this pool in 1963 was attributed to the following reasons:

1. Proximity of St. Croix River recreation area;
2. Isolated location of marsh lands adjacent to the pool;
3. Pollution making fish unpalatable and water unsuitable for body contact.

A variety of physical facilities have been developed in Pool 3 that exist mainly to serve boaters using the pool. These include:

Facility	Number
Small boat harobrs, marinas, boat clubs	2
Recreational sites	1
Recreational sites with ramps	4
Commercial recreational sites	4
Wildlife refuges	2

Except possibly for the recreational sites without ramps, which do not cater primarily to boaters, all of these facilities result from Corps' operations on the river that contributed the channel and stable water levels.

The wildlife refuges are examples of other recreational sites adjacent to Pool 3 that are not directly affected by Corps' operations.

Sport Fishing and Hunting. Neither the Wisconsin Department of Natural Resources (Fernholtz, personal communication) or the Iowa Conservation Commission (Brenton, personal communication) nor the U.S. Bureau of Sport Fisheries and Wildlife (Chase, personal communication) have recent, continuing data on sport fishing, sport hunting, and other recreational activity for Pool 3. The most precise data avaialble are for 1963 and appear in Table 40. The data are a composite of both Corps of Engineers and Bureau of Sport Fisheries and Wildlife visitation compilations for that year.

Although precise data on sport fishing are not available, attendants at each lock and dam make daily observations at 3:00 p.m. each day throughout the year of the number of sport fishermen observed from their work location. Annual data for the most recent years for which these records are available appear in Table 41. The table shows a wide variation in sport fishermen observed from Lock and Dam 3 since 1963. Because most sport fishermen observed from a lock and dam are downstream from the dam, most of the fishermen seen from Lock and Dam 3 are in Pool 4. Data on fishermen in Pool 3--as seen from Lock and Dam 2 are scanty and an insufficient number of years have been reported for any conclusions to be reached.

Table 41. Number of Sport Fishermen Observed Annually by Both Attendants From Lock and Dam Sites of Both Ends of Pool 3 on the Upper Mississippi River, 1960-1970

Year	Lock and Dam 2	Lock and Dam 2
1960	Not available	2627
1961	Not available	3284
1962	Not available	2733
		2596
		2830
1965	Not available	Not available
1966	Not available	Not available
1967	369	2510
1968	401	3013
1969	103	2714
1970	57	5752

Source: U.S. Corps of Engineers data published in the Proceedings of the Annual Meeting of the Upper Mississippi River Committee, 1960-1971

The rising water level in Pool 3 has increased the spawning areas for fish. In theory, this offers the potential for more sport fishing. However, the potential both for increased commercial and sport fishing in Pool 3 is probably partially offset by river pollution and turbidity from increased industrial activity along the perimeter of the pool and barge activity in it.

As the water levels in Pool 3 have been raised in Corps operations, habitat for residential and migratory waterbirds has also increased. This suggests the potential for greater bird hunting adjacent to Pool 3 and probably a lessening of hunting opportunities for small animals. Increased industrialization has operated to reduce this hunting potential. Unfortunately, no data were found that measure hunting activity in and adjacent to Pool 3.

Sightseeing and Picnicking. Recreational sites along the perimeter of Pool 3 facilitate sightseeing, picnicking, and hiking. While non-boating visitors to these sites might be there whether Corps' operations existed on the Upper Mississippi or not, virtually all of the activities at these sites by boaters are attributable to Corps' activities. In addition, visitors to overlooks at both Locks and Dams are a direct result of Corps' operations.

Cultural Impacts

There are a number of archaeological sites in Pool 3, which have been impacted by the activities of the Corps of Engineers. To date, only information on those located on the Minnesota shore have been gathered. These sites are:

1. 45 burial mounds on Prairie Island (797/802) of which 38 are now submerged and 7 others are subject to erosion because of the raised water level;
2. In and at a Village site on the southern tip of Prairie Island (797 R) which was destroyed in the construction of Lock and Dam 3;
3. Mounds and part of a village site which were destroyed in the construction of the Commissary Point recreational area.

One historic site has perhaps been affected by the Corps of Engineers activities. This is the site of the Le Sueur and Perrot French Trading Post which has been recoreded as being on the edge of the water on Prairie Island. All attempts to locate the site precidsely have failed. It is assumed that it is now under water.

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4. ANY ADVERSE ENVIRONMENTAL EFFECTS WHICH COULD NOT BE AVOIDED AS THE PROJECT WAS IMPLEMENTED

NATURAL SYSTEMS

Those adverse effects which may have come about as a result of the Corps' activities during construction and operation and maintenance of the 9-foot channel in the Pool 3 area would most likely be a result of one or more of the following:

1. Presence of the dam and/or lock;
2. The inundation of the lower portion of the pool;
3. The creation of a river-lake at the downstream portion of each pool (including Pool 3);
4. Maintenance activities;
5. Other, but not immediately identifiable factors.

The presence of the dam was felt when the Vermillion River was re-directed into a new channel. It is not known at this point if this dam prevents any species of fish from migrating, but the point requires further research. The roller gates are generally partially open; this will allow strong swimmers through the aperature. The immediate area of construction and the newer channels for entry into the locks from downstream would have seen a major disruption of the aquatic communities in the way.

The raising of the water level in the pool, as an intended result of the Corps' activities, flooded much bottomland as discussed earlier in this report. Though there was widespread inundation of haymarshes and some flooding of forested areas, there was not much cultivated farmland destroyed. The aerial phto survey of 1927 shows mostly forest area. These forests were harvested prior to flooding of the pool.

The creation of a river-lake in the downstream porti[illegible] have destroyed those organisms not tolerant of a loss of flowing water. Clams would probably have been burieddby the weight of their shells as the silt deposits increased with the slowing of the current. The silt would also have

clogged the siphons if present in too great a quantity. The slower habitat would have favored the increased production of rough fish over the reproductive capabilities of the game species.

The impacts of maintenance activities such as dredging, would be the major impact for Pool 3 over the longer time span. The short-term periodic increases in turbidity would have been only locally deleterious in the early years of dredging. These impacts of closing off the back-channels, the burying of benthic organisms or their being dredge up, the ultimate channelization are all deleterious effects of dredging. The aerial photos of 1927 again point out very well the amount of sediments carried down by erosion of the coulees adjacent to the pools, as does Figure 34. We have then, an unending raw material source to continue the need for dredging assuming the need for a 9-foot aviagation channel. Some of the spoil sites of recent years are becoming unsightly, are being overused and destroyed by boaters/picnickers/campers. This abuse speeds re-erosion.

SOCIOECONOMIC SYSTEMS

Assuming the past need for economical bulk shipping by barges was justifiable, then the impacts should have been all positive except for those persons displaced by purchase of lands designated to be flooded as the pool level rose to its design height.

One other adverse effect would have been the inundation of historical sites at the downstream tip of Prairie Island. The loss of the sites would have been unintentional since historians have worked the area for years trying to ascertain further dwelling sites of recent or archaeological historical interest.

Sites which are probably not affected include the site identified as GD 108 by the State of Minnesota Archeologist; and the sites which are potentially destroyable in Pool 3 are: GD 15, GD 122, GD 8, WB 34, WB 32, WB 33, and WB 21. Concern has been voiced by the State Archeologists office in the person of Jan Streif S-48 Ford Hall, University of Minnesota. Full identification of these sites by sections, quarter-sections, etc., are obtainable from this office.

5. ALTERNATIVES TO THE PRESENT OPERATIONS AND MAINTENANCE ACTIVITIES AND PRESENT FACILITIES

CHANNEL MAINTENANCE

1. Build another dredge to assist the Thompson, by having the new dredge capable of 3000 foot spoil line, with greater pumping capacity to throw spoil the requisite distance to minimize injurious impacts.
2. Encourage research into commercial use for dredge spoils.
3. Deposit spoil into islands with riprapping or other containment and/or landscaping to retard wind/water re-erosion.
4. Research the possibilities of moving the spoil at times of high water velocity directly into the channel itself in areas a little deeper than required. This may "move the problem downstream", but may be feasible in areas which should receive no distructive spoil on the terrestrial areas. Would require hydrologists/ biologists.
5. Move spoil out of flood plain whenever and wherever possible.
6. Survey probable dredge sites annually to minimize effects at dredging time.
7. Corps to study actual dredge sites for reworking the site to preclude need for future dredging. Modify dams, riprap, etc., This is intended for sites which require redredging every few years.
8. Study "delta" at each trouble spot with view of recommending direct action by the Soils Conservation Service. This is as needed as "beaver-dam" constructions up high in watersheds for flood control.

DAM OPERATION

No alternatives offered for this pool.

LOCK OPERATION

1. Allow recreational lockage, one up and one down, between commercial double-locking, if needed.
2. Hire "summer policemen" to identify and report careless and/or reckless boating during and around locking. This is getting to be a real hazard, and lockmen are too busy.
3. Establish toll system for commercial barge traffic.
4. Build an additional commercial lock in the unfinished auxiliary position, of the same depth, but of a double capacity to reduce the need for "double locking".

RECREATIONAL FACILITIES

1. Hire summer help to clena up government spoil area picnic beaches. These could be older teenagers/college students.
2. Install summer-only privy-type toilet facilities on those spoil areas which are used frequently for boat/campers.
3. Mark small boat channel from Sturgeon Lake ramp to main channel.

6. THE RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

1. Increased navigation has led to increased immigration into the floodplain by more people, which has the continuing effect of reducing the natural systems and increasing the commercially useful socioeconomic systems. The continued activities feed on each other in an increasing circle.
2. Higher Pool elevation in Pool 3 reduced the available terrestrial wildlife habitat, yet in the long run this area will go through a water-land succession anyway.
3. The creation of the lakes at the downstream portion of each pool has created a temporary depth which will be refilled by reduced ability of the slowed waters to carry the sediment load. As the lake portions fill, the flood-control capabilities of the dam are reduced. The reservoir capacity is reduced. Quick, locally severe rainfalls will be felt in greater numbers of pools.
4. Continued maintenance dredging will ultimately completely channelize the river, which will increase the hydraulic efficiency of the river to the point of a canal. (50 plus years).

Resource Implications for Socioeconomic Activities

Table 42 summarizes the major resource implications of continuing to operate and maintain the 9-foot channel in the St. Paul District. Resource implications are discussed in greater detail below.

[illegible]

Table 42 identifies the major first order direct benefits associated with lock and dam operation and dredging operations. These include employment in lock and dam dredging operations, maintenance of relatively stable water levels in each pool, and the presence of a navigable 9-foot channel in the St. Paul District. About 150 people are involved with lock and dam operations in the district and about 75 with dredging operations; thus, about

Table 42. First-Order Benefits and Costs to Socioeconomic Activities of Maintaining the Nine-foot Channel in Pool 3, Mississippi River

Socioeconomic Activity		Qualitative Summary of Socioeconomic Benefits and Costs	
General Category	Specific Activity	First-Order Socioeconomic Benefits	First-Order Socioeconomic Costs
Corps Operations	Lock and dam (L/D) operation	1. L/D employment 2. Stable water levels	1. Cost of L/D operation 2. Sedimentation behind dams and at head of flatwater pool
	Dredging Operations	1. Dredging employment 2. Nine-foot channel	1. Cost of dredging operation 2. Destruction of fish and wildlife habitat because of improper dredge spoil placement.
Industrial	Barge operation	1. Barge employment 2. Low-cost water transportation 3. Energy saving compared to alternate transportation modes 4. Decrease in air pollution compared to other modes.	1. Increased river turbidity 2. River pollution from oil and gasoline from barges 3. Hazard to small craft
	Commercial Dock	1. Dock employment 2. Attraction of barge-transportation-oriented firms that provide local employment	1. Increased river pollution from industrial activities along shore 2. Loss of riverfront property for recreational use
Recreational	Boating Activity	1. Increased safety of deeper channel for boaters	1. Decline in aesthetic appeal of riverscape
	Sport Fishing	1. Initially increased habitat for fish 2. Increased substrate for macroinvertebrates on wing dams	1. Increased sedimentation in fish habitat 2. Hazard of wing dams and barges

Table 42. First-Order Benefits and Costs to Socioeconomic Activities of Maintaining the Nine-Foot Channel in Pool 3, Mississippi River (Continued)

Socioeconomic Activity		Qualitative Summary of Socioeconomic Benefits and Costs	
General Category	Specific Activity	First-Order Socioeconomic Benefits	First-Order Socioeconomic Costs
Recreational (cont.)	Bird-watching	1. Initially increase habitat for waterfowl	1. Decreased waterfowl habitat from improper dredge spoil placement 2. Decrease in songbird habitat with removal of trees and brush, and joining of islands for industrial usage
	Sightseeing, picnicking, swimming	1. Increased number of potential swimming areas.	1. Decreased opportunities for miscellaneous recreational activities 2. River pollution from industrial and barge operation 3. Decrease in aesthetic appeal of river

225 people derive jobs and income directly from Corps' operations. The annual direct cost to taxpayers for lock and dam operations is $2,601,000 (FY 1970), and for dredging operations is $1,200,000. Specific environmental costs of the stable water levels in the pools and the 9-foot channel in the St. Paul District are an increase in sedimentation behind dams and wing dams and a reduction in fish and waterfowl habitat caused by current methods of dredge spoil placement.

Industrial Activities

As summarized in Table 40, the major direct impacts of Corps' operations on industrial activities are for barge transportation: How effective is barge transportation relative to other modes of transportation with respect to:

1. Energy use?
2. Air and water pollution?

Because the answers have major resource allocation implications for the Upper Mississippi River, these two questions are analyzed below in some detail. In addition, savings in transportation costs caused by barge movements are discussed.

Barge Transportation and Energy Use. Effective energy use is particularly important in light of the present, and probably continuing, energy crisis. It also affects air pollution which relates directly to transportation energy consumption.

At present transportation uses about 25 percent of the total U.S. energy budget for motive power alone. This use has been increasing at an average annual rate of about four percent per year.

In comparing the efficiency of energy use between various transportation modes, the term "energy intensiveness" is commonly used. Energy intensiveness is defined as the amount of energy (in BTU's) needed to deliver one ton-mile of freight. The following table compares the energy intensiveness of various modes of transportation (Mooz, 1973):

Freight Mode	Energy Intensiveness (BTU's/ton-mile)	Ratios of E.I.
Waterways	500	1
Rail	750	1.5
Pipeline	1,850	3.7
Truck	2,400	4.8
Air cargo	63,000	126.

From the table, motive energy is used more efficiently in water transportation. Therefore, under conditions of restricted petroleum energy availability, further use of barging on the Upper Mississippi and its tributaries is likely. Influencing this will be increased shipments of grain out of the St. Paul District and increased imports of coal and petroleum products into the region. Exports of grain to other countries and shipments to other parts of the U.S. are expected to increase. Energy demands in the Upper Midwest are also expected to rise. In addition, freight which is now only marginally involved in barging may shift from other forms of transportation to the less energy-intensive forms. This shift may also be expected to change existing concepts of the kinds of freight suitable for barging with consequent impact on storage facilities. In many cases, economic trade-offs may exist between the mode of transportation and the size of inventories considered to be suitable. If the costs of energy rise sufficiently, increased capital necessitated by use of the slower-moving barge transportation and increased capital tied up in inventory and storage space may be justified. If this occurs, other kinds of cargoes presently shipped by rail or truck or pipeline may be diverted to barge.

The role of the Upper Mississippi as a transportation artery is shown by the burden which would be placed on the rail system (as the major alternative transportation mode used to move heavy, high-bulk commodities) in the absence of barge traffic on the river. In 1972 an estimated 16,361,174 tons of various commodities were received and shipped from the St. Paul District. Under the simplifying assumption that the average box or hopper car carries 50 tons, this amounts to the equivalent of 327,223 railroad cars or some 3272 trains of 100 cars each or approximately nine trains each day of the year.

Barge Transportation and Air Pollution. Diesel engines are the most common power plants used by both tugboats and railroads. A large percentage of over-the-highway trucks use diesel engines as well. The diesel engine is slightly more efficient than the gasoline engine because of its higher compression ratio. Thus, less energy is used to move one ton of freight over one mile by diesel than by gasoline engines. Among users of diesel engines, barging probably is more efficient than either rail or truck.

The amount of air pollution caused by either diesel fuel or gasoline varies substantially only in the type of air pollution. The following table illustrates these pollution effects (U.S.P.H.S., 1968):

Type of Emission	Pounds per 1000 gallons diesel fuel	Pounds per 1000 gallons gasoline
Aldehydes (HCHO)	10	4
Carbon monoxide (CO)	60	2300
Hydrocarbons (	136	200
Oxides of Nitrogen (	222	113
Oxides of Sulfur (	40	9
Organic Acids (aectic)	31	4
Particulates	110	12

Based upon the energy intensiveness ratios shown earlier, a diesel train will produce 1.5 times as much air pollution and a diesel truck 4.8 times as much air pollution per ton-mile as a tug and barges. These arguments from barging and probably will be a portion of the reasoning applied to future expansion of barge operations on the Upper Mississippi River.

Barge Transportation and Cost Savings. A further benefit which can be attributed to the maintenance of navigation on the Upper Mississippi is in the savings in transportation costs, particularly for bulk commodities. Estimates of these savings have been made. One of these estimates the savings over the other various least-cost alternatives of between 4.0 and 5.4 mills per ton-mile (UMRCBS, 1970). It is generally recognized that bulk commodities, particularly those having low value-to-weight ratios, are appropriate for

barge transport. Coal, petroleum, and grain that have these characteristics are examples of such commodities that originate, terminate, or move through the St. Paul District pools on river barges. Future expansion of the barging traffic is expected as this report is being written. The probable opening of strip mines in the Montana, North and South Dakota areas will undoubtedly call for coal terminals on this portion of the Upper Mississippi River. A rail/barge terminal or two will almost be assured with the increasing feasibility of coal gasification technology. The cheap transportation of coal downstream is sure to attract interest from mass shippers. The Unit-Trains of coal from the west will transfer cargo along the Mississippi River as an expediency. There is bound to be a confrontation between barge interests and recreational interests.

Recreational Activities

Table 42 identifies the variety of recreational activities--from boating and sport fishing to sightseeing and sampling--that may be helped or hindered by Corps' operations. The Bureau of Outdoor Recreation is getting a Bill in 1974 to revive interest in a National Recreation Area encompassing the Mississippi River Corridor extending from Minneapolis/St. Paul through to St. Louis, Mo. The scenic, recreational boating, etc., activities will be of greater economic value to the economically depressed western portion of Wisconsin, and will give rise to locally important sources of income. These potential sources of revenue of immediate benefit to local interests will have to be weighed against increased commercial barge traffic, since the width of the river in the areas upstream of Lake Pepin would dictate a dangerous boat traffic pattern between private recreational boats and commercial shipping interests. Ideally, it would be desirable to place dollar values on each of the benefits and costs to the recreational activities cited in Table 40 to weigh against the benefits of barge transportation made possible by maintaining the 9-foot channel. Unfortunately, both conceptual problems and lack of precise data preclude such an analysis. The nature of these limitations can be understood by (1) looking initially at a theoretical approach for measuring the benefits and costs of recreational activities, and

(2) applying some of these ideas to the measurement of only one aspect of all recreational activities--sport fishing.

Benefits and Costs of Recreational Activities. Theoretical frameworks exist to perform a benefit-cost analysis of a recreation or tourism activity. One example is a study prepared for the U.S. Economic Development Administration (Arthur D. Little, Inc., 1967). Unfortunately, even this example closes with a "hypothetical benefit-cost analysis of an imaginary recreation/tourism project" that completely neglects the difficulty of collecting the appropriate data.

To an economist, applying even this theoretical framework to the 9-foot channel project presents both conceptual and data collection problems. For example, continuing to operate and maintain the 9-foot channel may hurt sport fishing because of the reduction in fish habitat. This means that the total value of sport fishing in the river should not be considered in the analysis. Rather, only the incremental increase or decrease in sport fishing attributable to present Corps; operations (not caused by the initial lock and dam construction) should be weighed against those operations.

This raises a second difficulty: How does one measure the total value of sport fishing on the river in order to start to measure the incremental portion attributable to Corps' operations? For sport fishing, various measures have been identified, each having its own drawbacks (Clawson and Knetsch, 1966): gross expenditures by the fishermen, market value of fish caught, cost of providing the fishing opportunity, the market value as determined by comparable privately owned recreation areas, and the direct interview method--asking fishermen what hypothetical price they would be willing to pay if they were to be charged a fee to fish.

If some average price per fisherman or trip were available, it still would be possible to assess the total value of sport fishing in the study area only if estimates of the number of sport fishermen or number of sport fishing trips were available. In the St. Paul District these estimates are available through sport fishery surveys for only three pools: Pool 4, Pool 5, and Pool 7. The most recent data available for these pools are for

the 1967-68 year (Wright, 1970); comparable data for 1972-73 have been collected, but are not expected to be published in report form until about December 1973.

Valuing Sport Fishing in the Study Area. A variety of studies have been done on recreation and tourism in Minnesota and the Upper Midwest during the past decade (North Star Research Institute, 1966; Midwest Research Institute, 1968; Pennington, et al., 1969). For purposes of analyzing sport fishing and other recreational activities on the Upper Mississippi River, however, they have a serious disadvantage; these studies are generally limited to recreationers who have at least one overnight stay away from home. In the case of the St. Paul District, with the exception of campers and boaters on large pleasure craft with bunks, virtually all river users are not away from home overnight and unfortunately are omitted from such studies.

Information is then generally restricted to that available in the UMRCC sport fishing studies such as those shown below for 1967-68 (Wright, 1970):

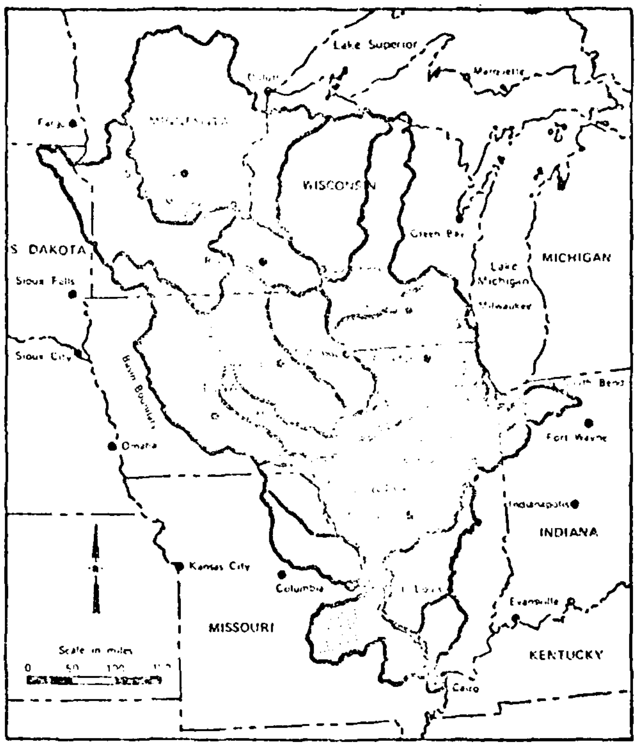
Pool Number	Total Number of Fishing Trips	Value at $1.50 per Trip*	Value at $5.00 per Trip**	Value at $10.00 per Trip***
4	169,361	$254,042	$846,805	$1,693,610
5	51,786	77,699	258,930	507,860
7	63,238	94,857	316,190	632,380

*Based on data in Supplement No. 1 (1964) to Senate Document 97 that provides a range of unit values of $0.50 to $1.50 a recreation day for evaluating freshwater fishing aspects of water resource projects.
**Based on data reported in the "1965 National Survey of Fishing and Hunting" that the average daily expenditure for freshwater sport fishing was $4.98 per day.
***Based on a more realistic value of 1973 costs.

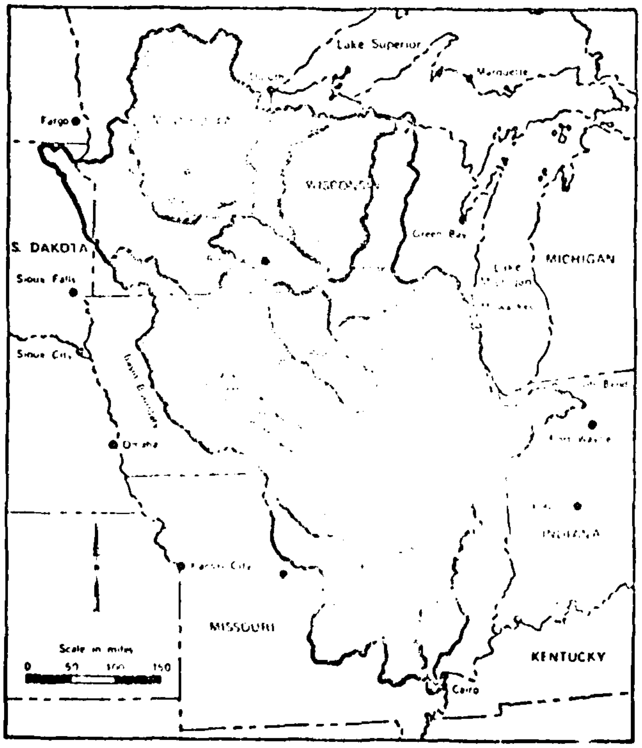
Thus, the sum of the values of sport fishing given above for these three pools varies from about $0.4 million to $2.8 million, depending upon the valuation of a fishing trip.

The comprehensive study of the UMRCBS in 1970, has created a series of figures seen here as Figures 34,35, and 36. which project the recreational needs into the years 2020 A.D. This portion of the Mississippi is within the CRITICAL DEMAND triangle illustrated so well in Figure 36. A recognition

1980



2000



2020

PROJECTED NET ANGLER-DAYS NEED

- Need Satisfied
- 1 - 299,000
- 300,000 - 599,000
- 600,000 - 999,000
- Greater Than 1,000,000

Source: UMRCBS, 1970

Figure 34. Projected Net Angler-Days Need in the Upper Mississippi River Basin, 1980, 2000, and 2020

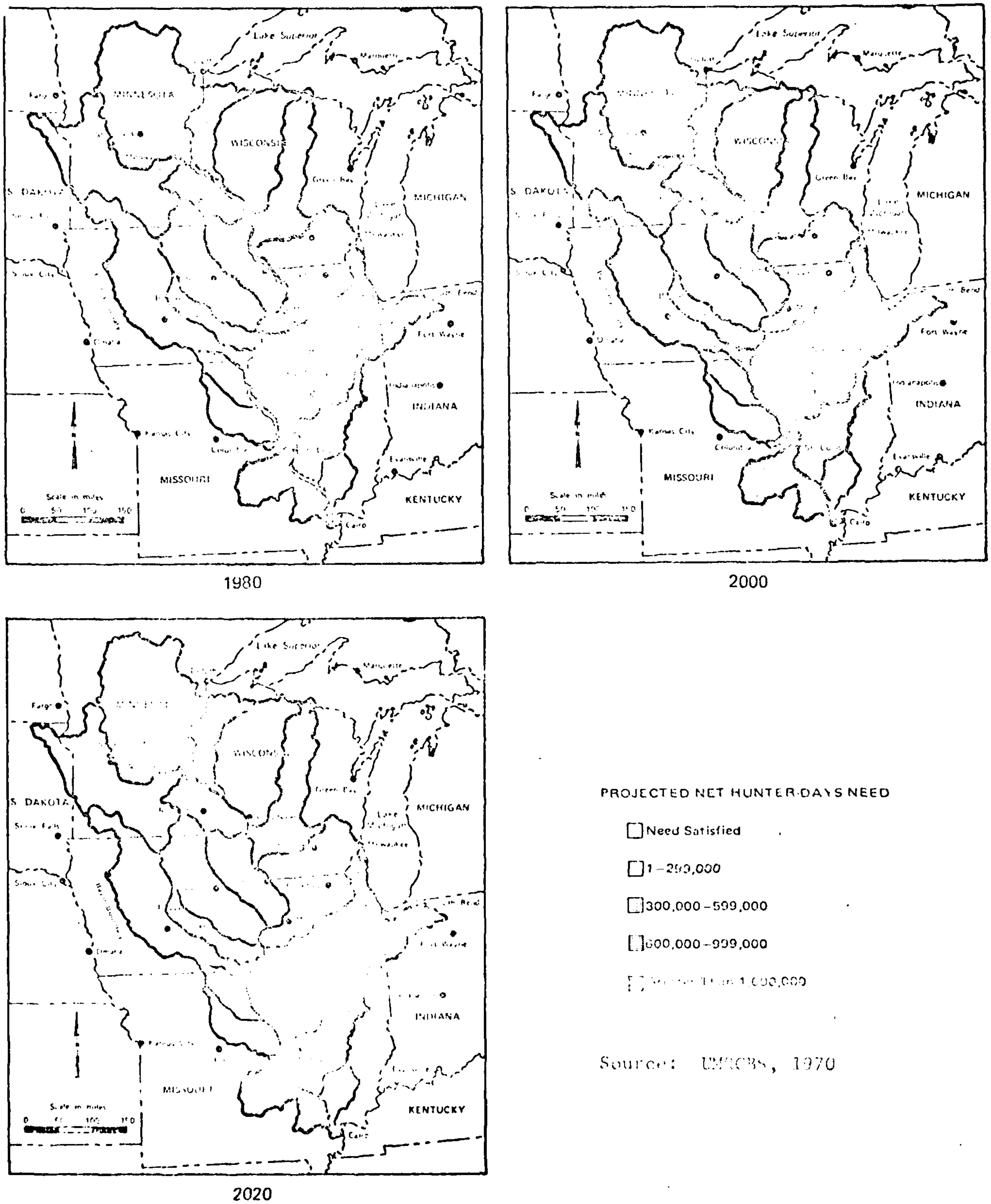
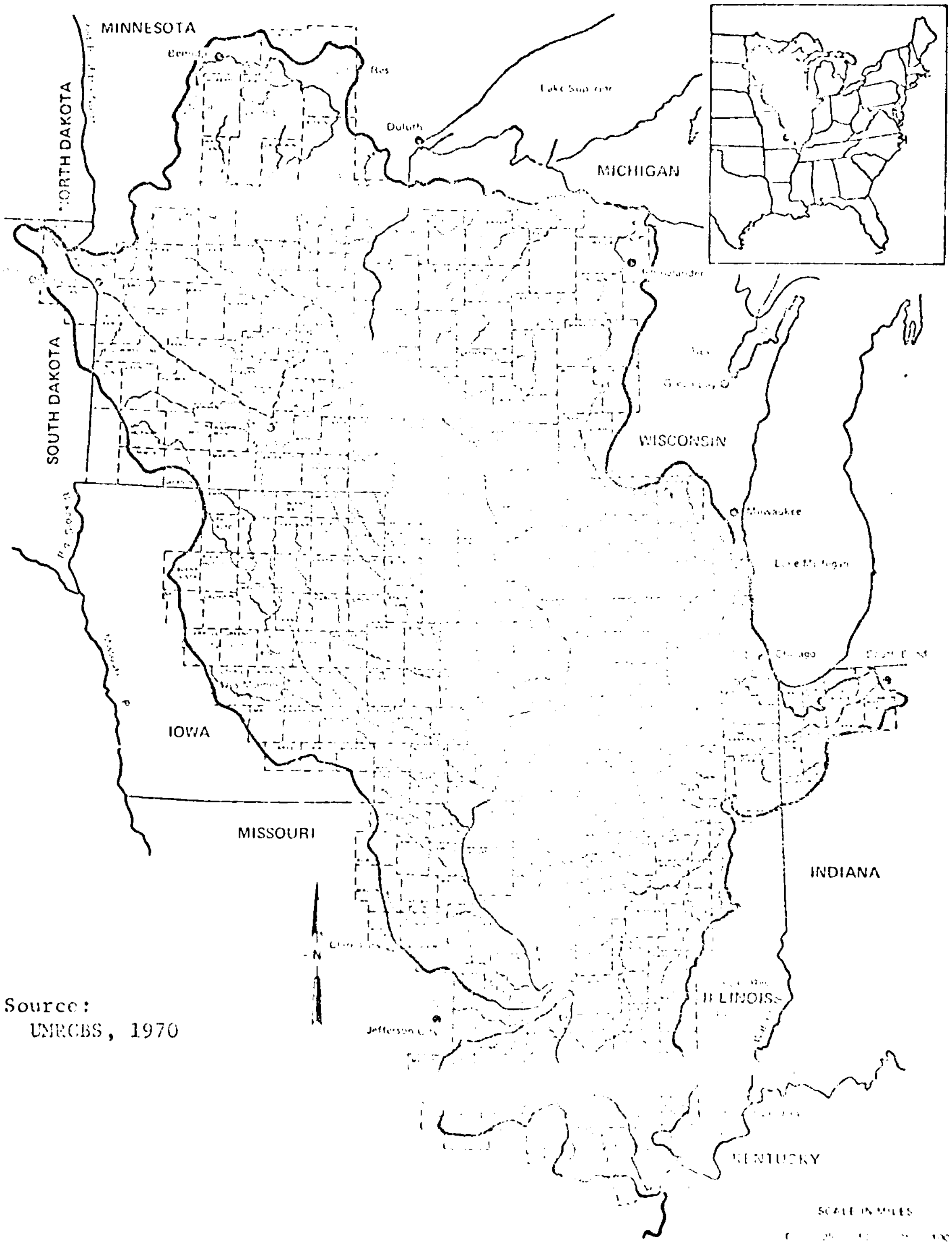


Figure 35. Projected Net Hunter-Days Need in the Upper Mississippi River Basin, 1980, 2000, and 2020



Source:
UMRCBS, 1970

Figure 36. Upper Mississippi River Basin Criti[illegible]

AD-A110 146   NORTH STAR RESEARCH INST MINNEAPOLIS MN ENVIRONMENTAL--ETC F/G 13/2
ENVIRONMENTAL IMPACT STUDY OF THE NORTHERN SECTION OF THE UPPER--ETC(U)
NOV 73 E F MILLER, K KRUMM   DACW37-73-C-0059

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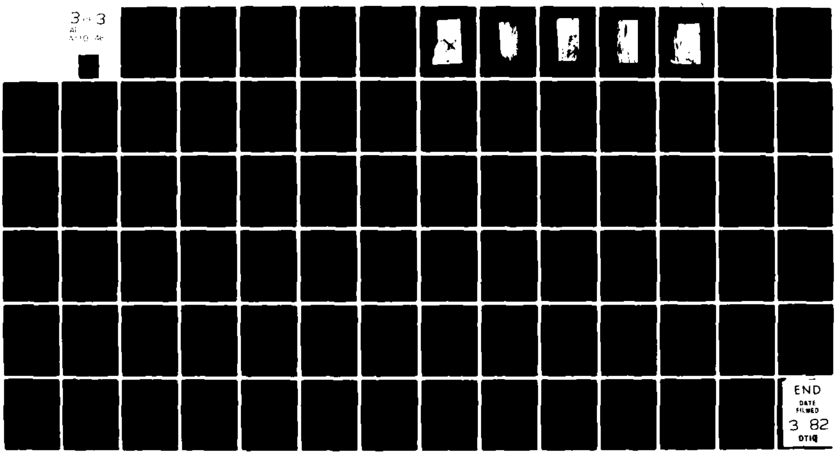

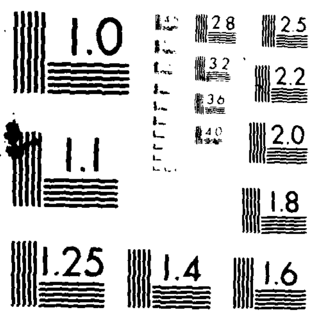
1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0

of these needs must be considered on a balanced basis when thinking of increased commercial barge traffic within the triangle. Hunting and fishing pressure will already be creating a need within fifty years on waters touching Pool 3.

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7. ANY IRRETREIVABLE AND IRREVERSIBLE COMMITMENTS OF RESOURCES WHICH HAVE BEEN INVOLVED IN THE PROJECT SINCE IT WAS IMPLEMENTED

RESOURCES LOST INCLUDING LAND-USE CHANGES

The time, labor, and material used in the construction of the Corps' facilities at Lock and Dam 3 have been irreversibly committed to the project. Labor, materials and money are being committed to the project for maintenance and for emergency-flood provisions. The costs of fuel (energy) must be included in all of the foregoing actions.

The areas flooded by construction of the dam and its pool, have reverted from haymarsh, forest and small self-sustaining farms to a wild condition either underwater or subject to flooding with small increments in water level in the downstream portions of the pool.

The "civilized" appearance of the river is irreversible, with the presence of the locks and dams, and the resultant commercial river traffic. This may be aesthetically displeasing to ultra-conservationists.

The redirecting of the Vermillion River from the original juncture with the Mississippi River at the site of Lock and Dam 3 is irreversible. It is capable of a rerouting in engineering terms, but the original channel is totally blocked at the terminal by the Lock.

SOCIOECONOMIC LOSSES

There were few losses on the economic side through the activities of the Corps. A relatively few farms were displaced, but the effects would have been minimal in consideration of the benefits.

Encampments of early explorers may have been lost by the work of the Corps of Engineers, but few archaeological sites were listed as having been destroyed or irreversibly altered.

8. SUMMARY OF RECOMMENDATIONS

DREDGE SPOILS

The worst long-term problem on the 9-foot channel project is the continued maintenance dredging and its spoils deposition. The current method of disposition along the edges of the navigation channel is a defeating and a losing battle. The high waters of the next year or even later in a single year will often cause resuspension of the fill. Methodology for removal from the flood-plain is becoming a necessity. A new large-capacity, long-throw dredge should be started as help for the Dredge Thompson. In those areas in which spoils are not recommended by the ecologists of Minnesota and Wisconsin DNR and Bureau of Sport Fisheries and Wildlife, the long-line dredge should be used. The need is now, not twenty years from now. Comparisons of shores of the main channel at 1938 (dams finished), when compared to present aerial photographs reveal the pressing current need. In Pool 3 it would be easier to dispose of spoils to "unit-trains" designed for hauling sand to commercial markets. With the railroads following both shores of the Mississippi River, this possibility should not be overlooked.

The use of spoils for recreational access "dike-roads" into backwater areas should be explored. The dikes would be engineered to permit water passage through sloughs, but would ease over-use of current sites now extant.

Research Troublesome Dredge Areas

There are particular areas in each of the pools that have to be dredged every few years, or have heavy quantities at recurrent types of floods. There should be a thorough analysis of frequency in an area, sequence of years of dredge work, structures involved, immediate sources of influx of materials for Soil Conservation Service cooperative work, etc. In aerial photographs numbered 49 through 53 of the August 1927 survey (pictures in Corps Files), the role of the several coulees in silt/sand run-off with rains, is very evident. There is enough sand coming from these few coulees to fill several spaces between wing dams on the Wisconsin shore.

Figures 37 through 42 are indicative of the location, types of erosion patterns, sedimentation sources, and practices seen and others recommended by the Soil Conservation Service. It is strongly urged that the Corps of Engineers/SCS conduct cooperative studies of the sources of sediment in order to ascertain some of the true costs of erosion through the coulees. A joint venture surely will give a more realistic Cost/Benefit ratio to rank the priority of coulee soil conservation as being urgent. Interviews with local representatives of the SCS indicate that soil conservation practices are currently retrogressive because farmers are not willing to place their crops into recommended contour limitations. The higher values of row-crops and the advent of larger farm machinery tend to pressure the farmer into the traditional yearly row-crops, planted in straight rows for ease in handling. Margins are now being expanded because of increased crop values.

Cover on Spoil Sites

Consideration should be given to seeding or sodding spoil sites soon after deposition from dredging activities. This could preclude wind erosion, retard water erosion at next high water, and would be aesthetically more pleasing.

Sounding the Channel

A complete sounding of Pool 3 should be undertaken. The last set of continuous survey soundings recorded on the Continuous Survey Charts are from 1947. This could be done as on-the-job training for students of hydrology during summers so to not interrupt the regularly scheduled work.

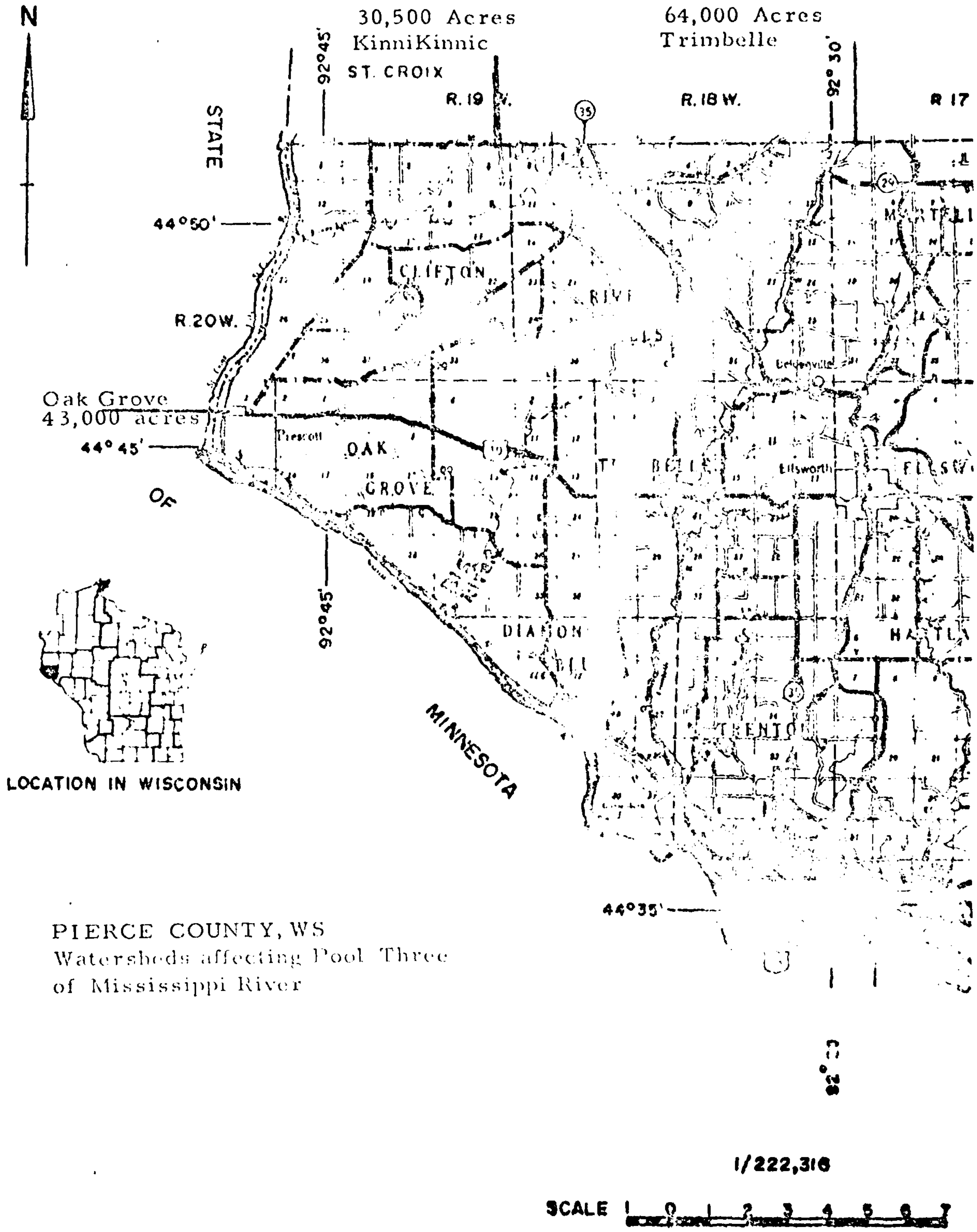

Figure 37. Pool Three Watersheds

Figure 38. A Dry Run Emptying into the Mississippi River at Pool Three.
Pierce County SCS Photo from 1957. There has been no improvement.

Figure 39. Sheet Erosion in Big Creek Watershed. Greater than 20 tons/acre of topsoil lost.
(SCS photo, courtesy Pierce County)

Figure 40. Sheet Erosion of Row-Crops in Pierce County,
Big River Watershed
(SCS photo)

Figure 41. Pierce County, WS Oak Grove Watershed, the Site of a Planned Subdivision. The location is scenic, while the water disposal and erosion problems are severe.

Figure 42. The Type of Contour Cropping Practiced on Few Farms, But Necessary on Almost all Farms in the Pierce County Watersheds Bordering the Mississippi River

MODIFICATION OF UPSTREAM APPROACH TO LOCK 3

There have been problems with the commercial barge operators in approaching the upstream portion of Lock 3 while travelling downstream. If there are high waters, below flood stage, but still in open flow configuration with the roller-gates out of the water, the cross currents from the Minnesota shore toward mid-channel are very difficult to overcome. Barges have sunk at the roller gates at Lock 3 because of the problem. Assistance was required by additional tow boats on May 15, 1973. After seeing the problem for the last three years, I would suggest diverting the main flow of the river across toward the roller gates near UM 797.5.

CONSTRUCTION OF NEW LOCK FOR COMMERCIAL TOWS IN AUXILIARY POSITION

The recreational/commercial lockage conflicts should justify the construction of a new lock toward midstream for commercial tows. The sills should remain the same depth, but the lock should accommodate a double-lock tow. The lock should be paid for by tolls on tows using the lock, as highway transporters pay higher taxes (mileage taxes, etc.).

PROTECT CLOSING DAM AT UM 800.9, ACROSS FROM WIND CREEK

The small channel at this point is beneficial to Sturgeon Lake biota because it permits freshwater to flow through the lake, preventing stagnation, permits immigration of macroinvertebrates, zooplankters, and allows foraging fish to move from main stem channel into and out of spawning/nursery areas.

The old riprapping is acting as a closing dam, but the channel is getting wider, and a new channel for the main stem flow is being cut. Maintain the flow, but stabilize the width erosion, and leave the "Y" branch in, since it gives new water to a very shallow area which could stagnate easily.

INITIATE PLANNED SEQUENTIAL PHOTOGRAMMETRY FLIGHTS FOR THE CORPS ON A THREE-YEAR REPEATING CYCLE

If a three-year cycle of planned photogrammetric flights were started now, closer attention could be paid to sequential changes in land forms, silt deposition, recreational overuse of beach sites, changes in health of ground cover, and to set a series of baseline data for planning of major future projects. These flights should be in the four seasons of the year of photography. The historical photographs of the 1927 flights are an example of value, yet these were done with relatively poor film emulsions and unsophisticated camera gear. Infrared as well as color photos would be of value.

STANDARD TRANSECT ECOLOGICAL STUDIES

The transects set up during this survey study should have carryover value in that they should be permanently marked with concrete posts or other relatively permanent markers. The Corps should then support three three-year studies on each of the pools at the standard transects for an understanding of the biota, and the implications of the roles played by Corps facilities and operations. This would include support for meetings to agree upon standardized collection techniques among the investigators, computer programmed accumulation of data and its varied analyses. These data would become the "property" of the United States as a data bank for baseline knowledge. No set of investigators in any one community along the river can understand the river, but the sum-total of the men and women engaged in river studies along the Mississippi could be of great value. Support of this type research is the proper role of the Federal Government.

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The major river corridors. December 1970. Metropolitan Council.

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Comparative statement of barge traffic on Mississippi and tributaries in St. Paul District, 1935-1971. Corps of Engineers.

Interstate operations of commercial fishing. Various years. Minnesota Department of Natural Resources.

Lists of industrial and commercial sites on the Mississippi River, various sources.

9. APPENDIX A - NATURAL SYSTEMS

METHODS OF DATA COLLECTION

Methods for Collecting Samples

Water samples were collected with a two-liter Kemmerer Bottle as a whole sample, and replicates came from the same filling. Plankton were collected by concentration of 19 liters of whole water onto membrane filters and into Palmer Cells for enumeration and identification. Benthic organisms were collected by use of Miller-Design artificial substrates, qualitative hand collections, and by grab samples with a modified Petersen Dredge. Primary productivity was measured by Light/ Dark Bottle methods and titrations per Vollenwieder. Primary Productivity were only measured at mid-pool and in Sturgeon Lake. Vegetation cover in acres was ascertained planimetrically from scaled aerial photographs, and ground verification. Data evaluation are still incomplete. They can be the basis for future studies.

Techniques Per Parameter

Temperature

Temperature was measured by thermister integral to DO Meter, checked with mercury-filled precision glass thermometer.

Dissolved Oxygen

DO was measured with a YSI membrane-probed meter. It was calibrated with the Winkler Azide-modification titration per USPHS Standard Methods, (13th Ed.).

Turbidity

Turbidity was measured with a model 2100 Hach Turbidimeter per USPHS Standard Methods.

Nitrites, Nitrates, Ammonia Nitrogen

These were measured using Hach proprietary chemicals and Colorimetric system.

pH, Conductivity

These were measured using a Leeds, Northrup pH meter, and a YSI Conductivity Bridge.

Suspended Solids and Dissolved Solids

These were measured gravimetrically on a Sartorius Balance after impingement upon membrane filters, drying, and evaporation of residues.

Percent of Ice Cover

Not determined, but should be studied in future.

MAP OF POOL THREE AND TRANSECT AND STATION LOCATIONS

The map of Pool 3 (see Figure 1), shows the locations of the transects in the pool, and the area of the pool. The transects run from track to track in most of the pool, but the AA transect runs from road to track. The AA transect is 1000 feet long on the water, at the power line crossing downstream of Lock and Dam 2. The landward side of the Minnesota shore stops at the road to the Dam.

Transect BB is at Prescott, Wisconsin (control point of Pool 3), is 1125 feet of river and 6075 feet of marsh/slough/river bottom woods. Transect XX across the St. Croix River is 495 feet.

Transect CC is upstream of Dam 3. The river portion is the only part laid out. The "S" curve in the river at that point is creating a little problem in laying out the Wisconsin side of the transect. This is private property, but permission to lay out the transect has been granted (verbal). The AA transect of Pool 4 will connect to this one due to river line of flow at this point. Figure 33 shows a similar transect at UM798.30.

POOL THREE TRANSECTS

TRANSECT A-A

This transect is located at river mile 815 above the Ohio River about 150 Feet downstream of the downstream wall of Lock & Dam #2. A siting along the two upstream base-legs of the Northern States Power Company Aerial Cable Crossing tower which then bisects the main channel of the Mississippi River was selected due to the ideal location of a relatively permanent landmark(The tower). The legs are located about 70' above high water marks therefor should be permanent. The transect then is visually clear across to the Railbed on the Washington County shore(Burlington-Northern Tracks). The reverse sighting into the area identified as Lake Rebecca Park in Dakota County is obscured by the relatively dense understory of the area known as Buck Island. The Cottonwood, Willow, Maple woods are combined with low-lying marsh areas. It is expected that this area will be used in the future as a recreation area for the city of Hastings MN and its nearby residents. The slough closed by the formation of the Lock & Dam #2 Dike is currently given the local name of Lake Rebecca. The width of Lake Rebecca is about 550 feet, while along the transect it is 275 feet. The water depths across the Main Channel portion of the transect varied between 12.0 feet and 20.0 feet(4-6.5Meters). The drop-off from either shore was as rapid as allowed by compaction contour of the deposited sands. Current velocities

create a hard, sandy shore at this transect immediately downstream of the maximum turbulence areas formed by the tailwaters of Dam#2. Petersen Dredge samples showed small numbers of Tubificidae, and Chironomidae Dipteran flies. The shoreline rock and/orwoody debris formed substrates for the adhesion of Trichopterans(Caddisflies), Ephemeropterans(Mayflies) and even a few Plecopterans(Stoneflies). The latter organisms were a real surprise, since their presence is generally indicative of waters which are minimally polluted. Taxonomic reduction of macroinvertebrates located in Pool Three are included in the Checklist for Pool Three Macroinvertebrates found within this Appendix D.

TRANSECT B-B

This transect is located downstream of the juncture of the Mississippi River and the St. Croix River, at Prescott, WS. The transect is sighted about 110 feet downstream of Coast Guard River Mile Marker for Mile 811 on the Minnesota shore of the main channel. The choice of this transect is again based upon an overhead power transmission line of the Northern States Power Co. Starting from the Wisconsin shore, The newly created Small Boat Harbor at Prescott is bisected by the transect, then the Main Channel. The main channel is about 550 feet wide, and has a depth of 6.5 Meters(maximum). Again a very quick drop-off in depth is seen at either shoreline, as the river is pinched at this point, creating excessive current velocities which would be strongly ero-

sional if the structures werent there for protecting against this action. The Corps of Engineers has riprapping along both shores. The riprapping is a good substrate for macroinvertebrates and their holdfast structures, as can be seen by referring to the Checklist of Macroinvertebrates in this Appendix, and in papers by Miller for Northern States Power Company(Miller 1970, 1971, 1972, 1973, 1974). Of an unseen and often unrecognized importance of the riprapping, is the substrate that they form for Protozoans, Micro-crustaceans, and attached Phytoplankton. The Mississippi River is highly eutrophic at this point, and the roles of Primary Producers, Secondary Producers, and Primary Decomposers is very actively fluctuating here.

Going inland, away from the main channel, the shoreline is a very typical floodplain forest composed of Cottonwood, Ash, Maple, and Elm trees, with an understory ranging from dense to medium dense,. for about 800 feet. The channel behind Prescott Island is then encountered, with the newly constructed barge fleeting area immediately downstream of the imaginary transect line. The island channel is 425 feet wide and very muddy and sandy, with a depth ranging between .5 and 1.0 Meter. After about 350 feet of forest which includes Basswoods now, an open area about 1000 feet across is now encountered. The open area is a combination of old dredge spoil, former marshland/open water, and emergent macrophyte succession topography. Another 1000 feet of forest is then traversed similar to that on the opposite side of the open area just passed, and then a drainage creek

(emptying former ox-bows during flood seasons) is crossed(0.5M deep). A natural haymarsh-hayfield is crossed that is about 400 feet long along the transect. The haymarsh is still being utilized by a local farmer for his animals. Vermillion Slough(Vermillion River) is now crossed. It is about 75 feet across, and approximates 0.5 to 1.5 Meters deep. Going along the transect, there is 750 feet of trees, 350 feet of active cornfield, and 370 feet of underbrush until the Minnesota railroad bed is encountered. All of the Minnesota side of the main channel is flood plain forest lands which are wet and undeveloped. They are considered to be future recreational lands in the Corps of Engineers Master Plan for Pool Three. There is a strong probability that these lands will be included in the National Recreation Area for the Upper Mississippi River. This plan has been consideration on several previous sessions of the United States Congress and is to be re-introduced by Senator Mondale(MN) in the 1974 sessions. The State of MN Planning personnel consider the area as a very much desired recreational opportunity within the fifty mile radius of the Twin Cities. A laterally compressed section of the area is seen in this Appendix. It is especially noticeable that there is only a five foot topographic rise across the transect until the Vermillion River is crossed. This indicates the fact of frequent inundation during normal spring overflows.

TRANSECT X-X(St. Croix River)

This is a special transect which bisects a major drainage area river as it enters the Mississippi River at Prescott, WS just upstream of the transect B-B just described. Transect X-X is only 450 feet wide, starting from the WS shore at the Corps of Engineers Guaging Station which controls the water levels for Pool Three, and crossing to the MN shore parallelling the Burlington Northern Railroad bridge crossing just upstream of the transect. The water depth of the St. Croix on the WS shore is a little over 7Meters, maintaining this depth across the transect until about 70 feet from the MN shore at which time the river shallows to about 5 Meters. The MN shore is known locally as Point Douglas, and is a naturally formed sand-bar which closes off most of the mouth of the St. Croix by depositional action of the Mississippi River. Both shores of the St. Croix are artificially structured at this point by Corps of Engineers, Railroad, and city of Prescott engineering structures. The overall water quality of the St. Croix is higher than the Mississippi, in that the St. Croix drains the first nationally designated "Wild-River", with few communities to contaminate its waters. The greatest pollutional aspects are from homes and recreational boating during the summer periods. The invertebrates collected are few in number due to the high current velocities, scouring action by commercial and recreational boats, and lack of stable substrate.

I feel that the St. Croix is the source of many of the pollution-sensitive macroinvertebrates which are found further downstream in Pool Three.

The predominating flora of the flood plain along the MN shore are those typically seen along the dredge spoil shores at waters edge. The WS shore is a combination of small boat docks, and sand-beaches with little vegetation other than grasses and sedges and a few spike-rushes. The bank is actually a hand-constructed stone wall about fifteen feet high, with the Pool Three Gauging station situated at the waters edge.

TRANSECT C-C

This transect is located at the upstream end of the guide wall leading into the Lock at Dam #3. It corresponds to Transect C-4 of the series of transects described and studied by Miller for Northern States Power and its Prairie Island Nuclear Generating Station which is going into power production as these reports are being written in 1973. The transect has been studied since May 1970. Along with this transect are those located further upstream, and those located immediately downstream and across the Vermillion and Cannon Rivers as they join the Mississippi River. Much data and information relative to flora and fauna in the waters of these rivers and their transects are contained within the Miller/NSP reports(NSP 1971, 1972, 1973, 1974). It is expected that Northern States Power will continue the aquatic studies for the next four years(Through 1978) and perhaps beyond.

River Falls, State University of Wisconsin has a terrestrial team carrying out concurrent studies for those areas thought to be within the range of any effects from the power plant. The results will be published by Northern States Power in the form of Annual Reports for the Environmental Monitoring Program of Prairie Island Nuclear Generating Plant. Copies are to be sent to the University of Minnesota Library, and the City of Minneapolis Public Library.

The transect starts on the Minnesota shoreline of the main channel of the Mississippi, using the tip of the upstream guidewall as the anchor point. This is at Mississippi River mile 797.0 above the Ohio River. The channel is 800 feet across at this point. The main current is strongest along the MN shore, with the current starting a strong across-the-channel switch right on the transect. The WS shore of the transect is a depositional area due to the drop in current carrying capacity along that shore. The whole transect layout can be seen in the following adaptation from a USGS Survey map. An angle had to be placed into the transect in order to bisect the river in the middle of an "S" curve, and yet not have an irrational flood plain transect. The first transect direction is 10°00" west of true north as sighted from the wall of the Dam#3. The second sighting was exactly 45°00" East of true north while standing on the shoreline(dike-top) sighted from Dam wall. While traversing the second portion of this transect line, you are in the marsh area owned by and generally recognized as Gantenbein Bottoms. Mr.

Gantenbein has been a commercial fisherman on this portion of the river, as was his father, an early commercial settler in the area. Mr Gantenbeins grandchildren are full grown and co-manage the area for hunting, fishing, and generalized conservation efforts. While carrying out the second line in this transect, permission has to be obtained from the Gantenbein family. If the work along the transect seems conservationally worthwhile, the family is generally generous in allowing permission to cross their lands and waters.

During the crossing of the second transit line, you are usually in water varying from centimeters through 2 meter depths. This is an area of old ox-bows created long ago by the meandering of the unstable river prior to shoreline stabilization by the Corps of Engineers at the turn of the Century. The transect is generally flooded each Spring, bringing in spawning endemic fishes from the main channel. The flooding causes an influx of sediment-rich flood waters, which drop their load while traversing the flood-plain at slower velocities, and while enmeshing with the plants of the marshland. The first 5500 feet contain a typical Typha-Scirpus-Juncus association varying with the water depths. In waters greater than 0.5 meters, Ceratophyllum demersum and Myriophyllum sp. had a tendency to choke open areas of water. In other open water areas, Nuphar sp. and Nelumbo sp were observed frequently. Many schools of minnows(young of the year) were observed. Included were young catfish, bullheads, carp, northern pike, crappies(black), and true minnows. Movement through the transect is inadvisable during the warmest

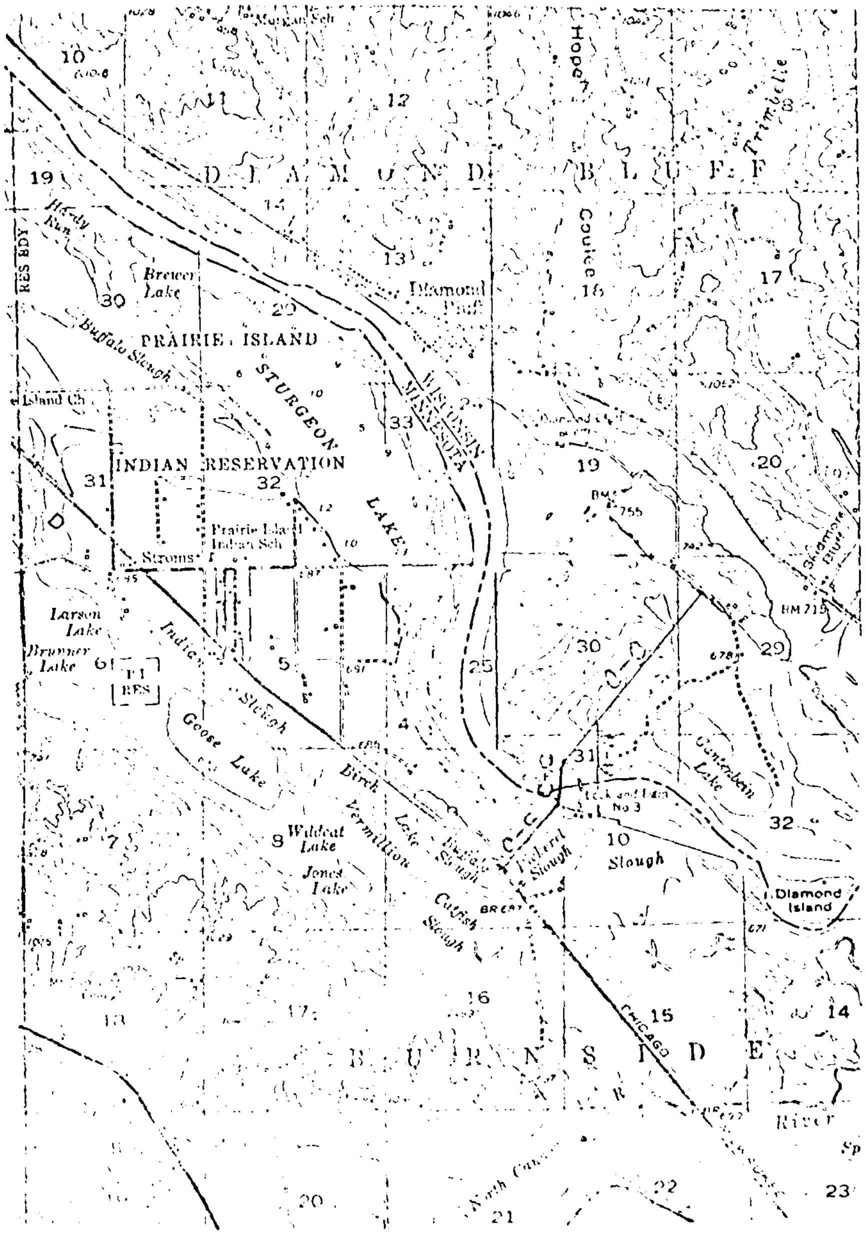
portion of the Summer, in that passage is almost precluded by the density of the *Typha-Scirpus* emergent growth. Use of a canoe is necessary, and even then traverse is very difficult. The final 500 feet of the transect runs against an abrupt 75 foot rise which is generalized along the Wisconsin shore at the mouth of the Trimbelle River delta formation.

The Minnesota shoreward traverse of the transect from the wall of the Lock, would be along a dike-road constructed during the building of the Lock & Dam number Three.

TRANSECT A-A(Pool Four)

This transect corresponds to transect D-3 as described in the series of Annual Reports by Miller/NSP relative to the Prairie Island Nuclear Power Plant. Though this transect is in reality a portion of the area studied by Dr Calvin Fremling as Pool Four, I bring out the description as given by Miller in the NSP studies as being more comprehensive at this point. This transect joins the second line of transect C-C just described, about 600 feet along the line going into Wisconsin.

This transect, A-A of Pool Four, is 500 feet downstream of Lock & Dam #3 Roller Gates. The biota of the river are described in the series of NSP reports, and in Table 21 of this report and the Checklist for Macroinvertebrates in this Appendix.



Transect C-C of Pool Three, and A-A of Pool Four of the Mississippi River, 1973.

WATER C ISTRY. TRANSECT A-A (1973)

DATE		TURBIDITY JTU	CONDUCTIVITY µmhos	pH	SUSPENDED Solids mg/l	ALKALINITY mg/l P	ALKALINITY mg/l T
June	MAX	21	428	8.5	39	0	134
	MIN	11	356	7.9	15	0	176
July	MAX	26	440	7.9	28	0	170
	MIN	10	393	7.3	11	0	155
August	MAX	17	348	7.6	123	0	133
	MIN	09	261	7.2	21	0	117
Septemb	MAX	10	368	7.6	47	0	136
	MIN	05	298	7.2	19	0	118
October	MAX	10	480	8.1	26	0	133
	MIN	06	440	7.9	17	0	123

(for gr ter details, see NSP 1974, Annual Report for 1973)

WATER CHEMISTRY TRANSECT A-A(1973 continued)

DATE		NITRITE NO_2 mg/1	NITRATE & NITRITE mg/1	AMMONIA NITROGEN mg/1	TOTAL PHOSPHATES mg/1	DISSOLVED SOLIDS mg/1	DISSOLVED OXYGEN mg/1
June	MAX	.026	.67	.55	.82	857	7.0
	MIN	.022	.58	.43	.65	564	5.1
July	MAX	.032	.73	.62	.78	765	8.4
	MIN	.030	.68	.55	.67	675	6.1
August	MAX	.038	.75	.59	.77	734	10.9
	MIN	.028	.67	.54	.68	654	5.4
September	MAX	.043	.77	.51	.72	843	7.8
	MIN	.032	.64	.45	.64	752	5.2
October	MAX	.031	.69	.52	.82	798	9.4
	MIN	.023	.62	.44	.74	756	7.6

WATER CHEMISTRY, TRANSECT B-3 (1973)

DATE		TURBIDITY jtu	CONDUCTIVITY µmhos	pH	SUSPENDED SOLIDS mg/l	ALKALINITY mg/l P	T
June	MAX	22	422	8.4	41	0	140
	MIN	12	374	7.9	17	0	137
July	MAX	27	438	7.8	29	0	168
	MIN	11	392	7.2	12	0	149
August	MAX	17	355	7.5	118*	0	132
	MIN	03	254	7.1	20	0	114
September	MAX	11	354	7.7	44	0	142
	MIN	04	299	7.1	17	0	115
October	MAX	11	487	8.0	25	0	135
	MIN	04	434	7.7	15	0	122

* Probably due to algal bloom evident
(for greater details, See NSP,1974 Annual Report for 1973)

WATER CHEMISTRY, TRANSECT B-B (1973 continued)

DATE		NITRITE NO_2 mg/1	NITRATE & NITRITE mg/1	AMMONIA NITROGEN mg/1	TOTAL PHOSPHATES mg/1	DISSOLVED SOLIDS mg/1	DISSOLVED OXYGEN mg/1
June	MAX	.023	.64	.53	.78	766	8.1
	MIN	.020	.59	.49	.67	744	6.3
July	MAX	.034	.76	.59	.76	778	8.9
	MIN	.023	.66	.52	.59	745	7.4
August	MAX	.042	.78	.65	.74	744	12.4
	MIN	.033	.73	.58	.63	730	7.3
September	MAX	.039	.81	.47	.65	789	8.3
	MIN	.026	.68	.37	.54	729	6.4
October	MAX	.032	.54	.50	.78	784	10.3
	MIN	.028	.45	.43	.64	733	7.9

WATER CHEMISTRY, TRANSECT X-X(1973,St.Croix River)

DATE		TURBIDITY JTU	CONDUCTIVITY umhos	pH	SUSPENDED SOLIDS mg/l	ALKALINITY mg/l P	ALKALINITY mg/l T
June	MAX	14	469	8.3	24	0	133
	MIN	07	443	8.0	17	0	129
July	MAX	11	406	8.1	22	0	136
	MIN	06	378	7.9	16	0	122
August	MAX	10	---	8.0	34	0	102
	MIN	03	---	7.6	22	0	87
September	MAX	09	344	7.7	23	0	99
	MIN	04	324	7.6	20	0	97
October	MAX	12	355	7.8	22	0	102
	MIN	07	342	7.6	20	0	97

(for greater details, See NSP,1974 Monitoring programs King Plant for 1973)

WATER CHEMISTRY, TRANSECT X-X (1973 continued)

DATE		NITRITE NO_2 mg/1	NITRATE & NITRITE mg/1	AMMONIA NITROGEN mg/1	TOTAL PHOSPHATES mg/1	DISSOLVED SOLIDS mg/1	DISSOLVED OXYGEN mg/1
June	MAX	.045	.57	.33	.56	---	9.0
	MIN	.023	.34	.23	.44	---	5.7
July	MAX	.040	.54	.34	.57	---	9.4
	MIN	.032	.46	.29	.44	---	5.9
August	MAX	.039	.53	.37	.56	---	9.1
	MIN	.036	.48	.31	.46	---	5.8
September	MAX	.039	.46	.19	.38	---	9.5
	MIN	.008	.09	.00	.09	---	6.1
October	MAX	.037	.44	.23	.36	---	8.9
	MIN	.021	.12	.03	.11	---	6.4

WATER CHEMISTRY, TRANSECT C-C (1973)

DATE		TURBIDITY JTU	CONDUCTIVITY µmhos	pH	SUSPENDED SOLIDS mg/1	ALKALINITY mg/1 P	ALKALINITY mg/1 T
June	MAX	29	443	8.4	49	0	148
	MIN	23	399	8.0	34	0	141
July	MAX	15	411	8.2	39	0	158
	MIN	12	386	7.7	27	0	150
August	MAX	24	340	8.1	13	0	151
	MIN	11	332	8.0	03	0	144
September	MAX	14	359	7.6	58	0	148
	MIN	05	332	7.2	22	0	113
October	MAX	14	476	8.1	34	0	147
	MIN	04	434	7.9	19	0	126

(for greater details, See EPA Monitor at LD/3 and NSP 1974, Annual Report for 1973)

WATER CHEMISTRY, TRANSECT C-C (1973 continued)

DATE		NITRITE NO_2 mg/1	NITRATE & NITRITE mg/1	AMMONIA NITROGEN mg/1	TOTAL PHOSPHATES mg/1	DISSOLVED SOLIDS mg/1	DISSOLVED OXYGEN mg/1
June	MAX	.022	.68	.47	.54	564	8.4
	MIN	.019	.59	.38	.49	533	6.3
July	MAX	.039	.79	.54	.72	632	9.0
	MIN	.031	.73	.47	.69	598	8.5
August	MAX	.032	.26	.61	.39	433	12.4
	MIN	.021	.23	.51	.34	408	7.2
September	MAX	.039	.28	.19	.35	489	11.8
	MIN	.035	.26	.15	.24	476	8.0
October	MAX	.033	.56	.34	.42	467	9.9
	MIN	.022	.43	.29	.38	439	7.4

WATER CHEMISTRY TRANSECT A-A(POOL FOUR,1973)

DATE		TURBIDITY JTU	CONDUCTIVITY µmhos	pH	SUSPENDED SOLIDS mg/1	ALKALINITY mg/1 P	ALKALINITY mg/1 T
June	MAX	33	452	8.2	42	0	151
	MIN	26	402	8.0	33	0	143
July	MAX	16	410	8.2	37	0	155
	MIN	14	384	7.5	22	0	149
August	MAX	11	339	8.0	16	0	155
	MIN	09	336	7.9	06	0	146
September	MAX	10	354	7.5	61	0	151
	MIN	06	335	7.1	25	0	143
October	MAX	16	465	8.0	33	0	152
	MIN	03	422	7.8	16	0	132

(For greater details, See Transect D-1 in NSP 1974, Annual Report for 1973)

WATER CHEMISTRY. TRANSECT A-A (POOL FOUR, 1973 continued)

DATE		NITRITE NO_2 mg/l	NITRATE & NITRITE mg/l	AMMONIA NITROGEN mg/l	TOTAL PHOSPHATES mg/l	DISSOLVED SOLIDS mg/l	DISSOLVED OXYGEN mg/l
June	MAX	.054	.73	.44	.64	534	8.7
	MIN	.039	.69	.38	.58	489	7.3
July	MAX	.041	.78	.31	.50	567	9.4
	MIN	.035	.64	.24	.45	543	8.8
August	MAX	.032	.24	.49	---	740	10.2
	MIN	.024	.23	.45	---	713	9.5
September	MAX	.042	.28	.20	.33	643	8.5
	MIN	.035	.26	.15	.28	589	8.1
October	MAX	.055	.45	.33	.54	598	9.6
	MIN	.041	.39	.29	.51	545	8.7

Check List of Macroinvertebrates collected in Pool #3 during the years 1970, 1971, 1972, 1973. (X indicates presence)

TAXON	1970	1971	1972	1973
Sponges:				
1. Spongillidae	X	X	X	X
Flatworms:				
2. Dugesia tigrinum	X	X	X	X
Bryozoans:				
3. Cristatella mucedo	X	X	X	X
4. Plumatella repens	X	X	X	X
Worms:				
5. Haplotaxidae	O	X	X	X
6. Limnodrillus sp.	X	O	X	O
7. Branchiura sowerbyi	X	O	O	O
8. Tubifex tubifex	X	X	X	X
9. Aelosomatidae	X	O	X	X
Leeches:				
10. Dina cf. fervida	O	X	X	O
11. Dina sp.	O	X	O	O
12. Erpobdella punctata	X	X	X	X
13. Erpobdella sp.	X	O	O	O
14. Glossiphonia complanata	O	X	X	O
15. Helobdella fusca	O	X	X	X
16. Helobdella stagnalis	X	X	X	X
17. Placobdella montifera	O	X	X	X
18. Placobdella parasitica	X	X	X	X
19. Placobdella reducta	O	X	O	O
20. Placobdella rugosa	O	X	X	O
Snails:				
21. Goniobasis sp.	X	O	X	X
22. Physa heterostropha	X	O	X	X
23. Pleurocera cf acuta	O	X	X	X
24. Pseudosuccinea sp.	X	O	O	O
25. Ferrissia fusca	O	X	X	X
26. Ferrissia cf laeviplex	X	O	X	X
27. Ferrissia sp. 1	O	X	O	O
28. Gyraulus sp. 1	O	X	O	O

CONTINUED NEXT PAGE

Checklist of Macroinvertebrates(Continued)

TAXON	1970	1971	1972	1973	
Clams:					
29. Amblema raraplicata	X	X	X	X	
30. Quadrula pustulosa	X	X	X	X	
31. Pleurobema coccineum	X	X	X	X	
32. Lampsilis siliquoidea	X	X	X	X	
33. Lampsilis ovata ventricosa	X	X	X	X	
34. Proptera alata	X	X	X	X	
35. Fusconia undata	X	X	O	O	
36. Anodonta gigantea	O	X	X	X	
37. Musculium spp	X	X	X	X	
38. Pisidium spp	X	X	X	X	
Amphipods:					
39. Hyalella azteca	X	X	X	X	
40. Gammarus gammarus	X	O	X	X	
41. Gammarus fasciata	X	O	O	O	
42. Gammarus lacustris limnaeus	O	O	X	X	
Isopods:					
43. Asellus militaris	X	X	X	X	
44. Asellus sp.	X	O	O	O	
Crayfish:					
45. Orconectes virilis	X	X	X	X	
46. Orconectes spp	O	O	X	X	immature
Stoneflies:					
47. Isoperla sp	X	O	X	X	
48. Isoperla bilineata	O	O	X	X	
49. Perlodes sp.	X	O	O	O	
Mayflies:					
50. Amaletus lineatus	O	X	O	O	
51. Amaletus ludens	O	X	X	X	
52. [illegible]	O	X	X	O	
53. Baetis brunneicolor	O	X	X	X	
54. Baetis intercalaris	O	X	O	X	
55. Baetis sp #1	X	X	X	O	
56. Caenis sp #1	X	X	X	X	
57. Ephemorella temporalis	O	X	O	X	
58. Ephemerella sp #1	X	X	X	X	

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Checklist of Macroinvertebrates (continued)

TAXON	1970	1971	1972	1973
59. Paraleptephlebia sp	O	X	X	X
60. Pseudocloeon parvulum	O	X	X	X
61. Pseudocloeon sp#1	X	X	X	X
62. Pseudocloeon myrsum	O	X	X	O
63. Tricorytodes atratus	O	X	X	X
64. Tricorythodes sp #1	O	X	X	O
65. Potamanthus sp #1	O	X	X	X
66. Campsurus sp #1	O	X	O	O
67. Heptageneia aphrodite	O	X	O	O
68. Heptagenia diabasia	O	X	X	X
69. Heptagenia flavescens	O	X	X	X
70. Heptagenia juno	O	X	O	O
71. Heptagenia maculopennis	O	X	O	O
72. Heptagenia marginalis	O	X	O	X
73. Stenonema ares	O	X	X	X
74. Stenonema canadense	O	X	O	X
75. Stenonema candidum	O	X	O	O
76. Stenonema carolina	O	X	O	O
77. Stenonema femoratum	X	X	X	X
78. Stenonema gildersleevei	O	X	X	X
79. Stenonema heterotarsale	O	X	O	O
80. Stenonema interpunctatum	O	X	O	O
81. Stenonema ithaca	O	X	X	X
82. Stenonema lineatus	O	X	O	O
83. Stenonema luteum	O	X	X	X
84. Stenonema nepotellum	O	X	O	O
85. Stenonema pulchellum	O	X	X	X
86. Stenonema rubromaculatum	O	X	O	X
87. Stenonema rubrum	O	X	X	X
88. Stenonema tripunctatum	O	X	O	O
89. Stenonema sp #1	X	X	O	O

CONTINUED ON NEXT PAGE

Checklist of Macroinvertebrates (Continued)

TAXON	1970	1971	1972	1973
Dragonflies:				
90. Gomphus sp # 1	X	X	X	X
Damselflies:				
91. Amphigrion saucium	O	X	X	X
92. Argia emma	X	X.	X	X
93. Ischnura sp #1	X	O	O	X
94. Hyponeura sp #1	X	O	O	O
Caddisflies:				
95. Cheumatopsyche campyla	O	X	O	X
96. Cheumatopsyche sp#1	X	X	X	X
97. Hydropsyche aerata	O	X	X	X
98. Hydropsyche arinale	O	X	X	X
99. Hydropsyche bettini	O	X	O	O
100 Hydropsyche bifida	O	X	O	O
101 Hydropsyche cacnis	O	X	O	X
102 Hydropsyche frisoni	X	X	X	X
103 Hydropsyche hageni	O	X	O	O
104 Hydropsyche orris	X	X	X	X
105 Hydropsyche recurvata	O	X	O	O
106 Hydropsyche simulans	X	X	X	X
107 Hydropsyche slossonae	O	X	O	O
108 Macronemum atratum	O	X	O	O
109 Macronemum sp #1	O	X	X	X
110 Potomyia flava	O	X	O	O
111 Agraylea multipunctata	X	X	X	X
112. Oxyethira sp #1	O	X	O	O
113. Hydroptilidae sp#1	O	X	X	X
114. Neureclipsis crepuscularis	X	X	X	X
115. Neureclipsis sp#1	X	X	X	X
116. Polycentropus centralis	X	X	X	X
117. Polycentropus cinereus	O	X	X	X
118. Polycentropus flavus	O	X	O	O
119. Polycentropus interruptus	X	X	X	X

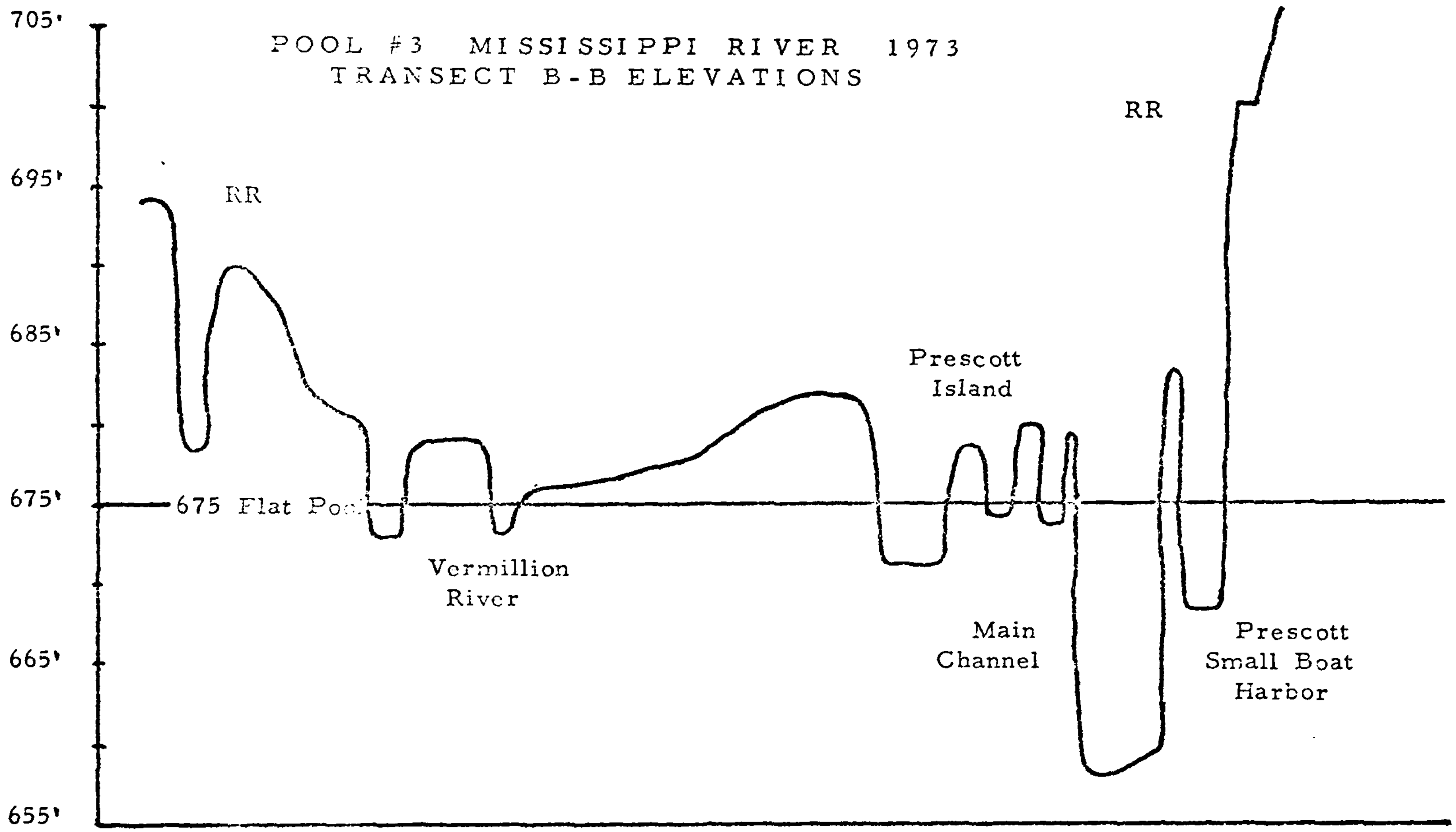
CONTINUED ON NEXT PAGE

Checklist of Macroinvertebrates (continued)

TAXON	1970	1971	1972	1973
120. Polycentropus placidus	O	X	O	O
121. Polycentropus remotus	O	X	X	X
122. Polycentropus Sp#1	X	X	X	X
123. Psychomyia flavida	O	X	O	O
124. Psychomyiidae G#A	X	O	X	X
125. Athripsodes tarsi punctatus	X	X	X	X
126. Athripsodes sp#2	X	O	O	O
127. Leptocella diarina	O	X	O	O
128. Leptocella sp#1	O	X	O	O
129. Lepidostoma sp#1	O	X	O	O
130. Limnephilus sp 1	O	X	O	O
131. Pycnopsyche subfasciata	O	X	X	X
132. Pycnopsyche sp 1	X	O	O	O
133. Astenophylu argus	O	X	O	O
134. Phryganeidae GS	O	X	O	O
135. Oecetis sp 1	X	O	O	X
Beetles:				
136. Dytiscidae GS	X	O	O	X
137. Rhizelmis sp	X	O	O	O
138. Neoelmis sp	O	X	O	O
139. Graphoderes sp	O	X	O	O
140. Microcylloepus sp	O	X	X	X
141. Chrysomelidae GS	O	X	O	X
142. Elsianus sp 1	O	X	O	O
143. Lara sp	O	X	O	O
144. Narpus sp	O	X	O	O
145. Haliplidae GS	O	X	O	O
146. Hydr[illegible]	O	X	[illegible]	[illegible]
147. Berosus sp	O	X	X	X
148. Hydrochus sp	O	X	O	O
149. [illegible] sp	O	X	O	O
150. Hydrobius sp	O	X	O	O
151. Neohydrophilus castus	O	X	O	O
Dipterans:				
152. Chironomidae GS	X	X	X	X
153. Tanytarsus	X	not taxonomically reduced in 71, 72, 73		
154. Stictochironomus	X	"		
155. Cryptochironomus	X	"		

Checklist of Macroinvertebrates (continued)

TAXON	1970	1971	1972	1973
Dipterans:				
152. Chronomidae GS	X	X	X	X
153. Tanytarsus	X	(not taxon reduced in 71, 72, 73.)		
154. Stictochironomus	X		"	
155. Cryptochironomus	X		"	
156. Parachironomus	X		"	
157. Dicrotendipes	X		"	
158. Glyptotendipes	X		"	
159. Coryneura	X		"	
160. Thienemaniella	X		"	
161. Cricotopus	X		"	
162. Eukieferiella	X		"	
163. Psectrocladius	X		"	
164. Pentaneura	X		"	
165. Simulidae GS	X	X	X	X
Lepidopterans:				
166. Pyralidae GS	O	X	O	O
Hemipterans:				
167. Plea striola	O	X	O	O
168. Tricorixa sp 1	X	X	X	X
Water Mites:				
169. Hydracarina sp. 1				
Neuropterans:				
170: Climacia areolaris	O	X	O	X



Minnesota Rail Embankment to the Wisconsin Rail Embankment is ca. 6,750 Feet
scale 1,000'/inch

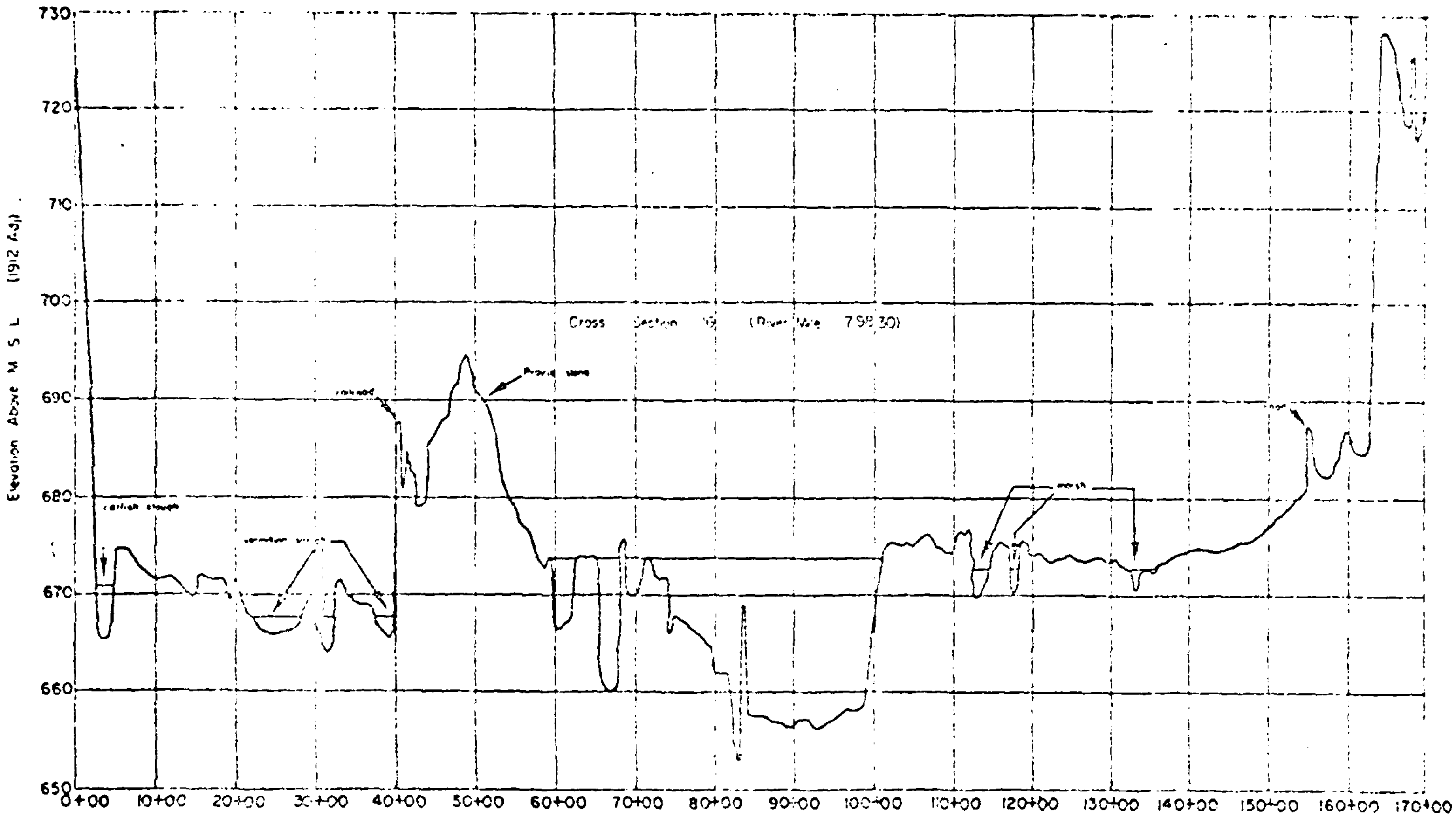


Figure . Typical Mississippi River Cross-Section Profile near Prairie Island(UM798.3)
(adapted from NSP, 1973)

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Methods of Data Collection

The data collected and analyzed for the socioeconomic portion of this report came essentially from published sources and to a lesser extent from interviews, correspondence and collections of unpublished statistics.

Among the sources utilized were: (1) the U. S. Corps of Engineers' publications and working data used by the Corps in its operations, (2) data supplied by the Minnesota State Archaeologist, (3) information and publications from the Minnesota State Historical Society and County Societies, (4) publications of the Upper Mississippi River Basin Coordinating Committee, and (5) others.

Data from these sources were abstracted as applicable to Pool 3 and then analyzed. Analysis included preparation of inventories where feasible and the keying of social or economic data to locations within the pool as identified on Corps of Engineers navigation charts of the pool.

After preliminary analysis and organization the results were shown to the principal investigators for Pool 3 in order to insure that the results, conclusions and supporting facts are properly coordinated with other sections of the report.

Study Limitations and Exclusions

Due to limitations of time and funds available, the socioeconomic study limited itself to a consideration of published sources and unpublished data in the immediate St. Paul and Minneapolis area. Although there were many ancillary areas of interest to an economist, every effort was made to keep to those subjects immediately germane to the economic and social effects of Corps of Engineers' activities in each pool.

A further factor which placed limiting parameters on this report was the fact that much of the economic and social data available are on a district- or subdistrict-wide basis. Therefore, in several cases somewhat arbitrary limiting assumptions and definitions had to be made. This will be more apparent in pool reports other than Pool 3 although implicit in much of the Pool 3 data is the fact that the data used are not always demonstrably confined to that single pool.

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National Register of Historic Places

Archaeological and Historic Sites in Minnesota in the Study Area along the Mississippi, Minnesota, and St. Croix Rivers Which are Now Listed in the National Register of Historic Places

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Recent Archaeology

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IOWA

Early Survey Work

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Studies in the late 1800's: The Lewis and Hill Survey

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Archaeological and historic sites of importance consist of such diverse elements as prehistoric village sites, petroglyphs (rock pictures), burial mounds, log cabins, forts, and so forth. Sites of significance may date from thousands of years ago to very recent times. Interest in studying elements of human history also varies as much with the times as interest in studying elements of natural history.

STUDIES IN THE LATE 1800's: THE LEWIS AND HILL SURVEY

Fortunately for our study now there was a strong interest in the late 19th Century in burial mounds; a massive study was pursued for approximately 20 years by Alfred J. Hill and Theodore H. Lewis. The extent of their work is best understood by examining a few of their manuscripts, a few samples of which are reproduced in this report. In 1928, Charles R. Keyes wrote of their accomplishments:

> "The great extent of the archeological survey work accomplished by Lewis and Hill cannot be appreciated except through an extended examination of the large mass of manuscript material that has been preserved. This consists approximately of the following forty leather-bound field notebooks well filled with the original entries of the survey; about a hundred plats of mound groups drawn on a scale of one foot to two thousand; about eight hundred plats of effigy mounds (animal-shaped mounds from Minnesota, Wisconsin, Iowa, and Illinois) on a scale of one foot to two hundred; about fifty plats of "forts" (largely village sites of the Mandan type) and other inclosures on a scale of one foot to four hundred; about a hundred large, folded tissue-paper sheets of original, full-size petroglyph rubbings with from one to six or more petroglyphs on each; about a thousand personal letters of Lewis to Hill; four bound "Mound Record" books made by Hill and in his handwriting; eight large, well filled scrapbooks of clippings on archeological matters made by Lewis; numerous account books, vouchers, and other miscellany...

"A single sheet of summary found among the miscellaneous papers of the survey, apparently made by Lewis, is eloquent in its significance. Tabulated by years and place of entry the mounds alone that were actually surveyed reach a grand total of over thirteen thousand--to be exact, 855 effigy mounds and 12,232 round mounds and linears...

"The survey is quite full for Minnesota, where work was done in all but three counties of the state, resulting in records of 7,773 mounds, besides a number of inclosures... much information was also gathered from the river counties of Iowa, Nebraska, Kansas, and Missouri. In Wisconsin the survey touched more than two-thirds of all the counties, mostly in the field of the effigy mounds in the southern half of the state, where the records supply detail for no less than 748 effigies and 2,837 other mounds. Iowa was explored most fully in the northeastern counties as far south as Dubuque, yielding data on 61 effigy mounds, 553 other mounds, and several inclosures. ...the survey yielded its richest results in Minnesota, the eastern parts of the Dakotas, northeastern Iowa, and the southern half of Wisconsin..." [Surveys were also conducted in the Dakotas, Manitoba, Missouri, Nebraska, Kansas, Illinois, Indiana, and Michigan--in all, eighteen states.]

"The strength of the survey consists, first of all, in the dependability of Lewis as a gatherer of facts... he worked as a realist, measuring and recording what he saw with painstaking accuracy and unwearying devotion... And the fact that these surveys were made at a time when a large number of mound groups that have since disappeared, or all but disappeared, were still intact, gives the work of Lewis and Hill an incalculable worth... So far as Iowa is concerned, something like half of the antiquities of the northeastern part of the state are recoverable only from the manuscripts of the Northwestern Archeological Survey..."

A typical description of the reporting format followed by Lewis and Hill is reproduced here:

[IN: MOUNDS IN DAKOTA, MINNESOTA AND WISCONSIN]

3. OTHER MOUNDS IN RAMSEY COUNTY, MINNESOTA.

At the lower end of the Pig's Eye marsh already mentioned, there stood (April, 1868) an isolated mound, not situated on the bluffs, but below them, near their foot, at the highest part of the river bottom on the sloping ground half-way between

the military road and the road-bed of the St. P. & C. R. R., then in course of construction, and distant about three hundred and fifty feet southward from the culvert on the former. It was in a cultivated field, and had itself been plowed over for years; yet it had still a mean height of six and a half feet; its diameter was sixty-five feet. The top of it was only thirty-one feet above the highwater of the Mississippi, according to the levels taken by the railroad engineers. The location of the mound, according to U. S. surveys, was on the N. 1/2 of SE. 1/4 of Sec. 23, T. 28, R. 22, and about one mile north of Red Rock landing. Mr. J. Ford, one of the old settlers of the neighborhood, said that a man named Odell had, some years previously, dug into it far enough to satisfy his curiosity, as the discovery of human bones clearly proved it to have been built for sepulchral purposes.

7. MOUNDS AT PRESCOTT, WISCONSIN.

At the angle formed by the confluence of the St. Croix and Mississippi rivers, on the eastern bank of the former, is the town of Prescott, Wisconsin. On May 13, 1873, three hours' time was employed in making such reconnaissance survey as was feasible of the mounds which stretch along the bluff on the Mississippi there. The smallest of them was about twenty-five feet diameter and one foot high, and the largest fifty-six feet diameter and four feet high, as nearly as could be then ascertained.

Pictographs were common on caves along the Mississippi River bluffs. Lewis and Hill recorded their locations and frequently the pictures themselves. Although specific reference was made to them in Houston, Winona, Washington, and Ramsey counties in Minnesota and Alamakee and Clayton counties in Iowa, it would be unwise to assume that they were limited to these locations.

Captain Carver, in 1766-67 explored a cave (in present day Ramsey County) as being of "amazing depth and containing many Indian hieroglyphics appearing very ancient." The cave, called by the Dakota "Wakan-teebe", became a popular tourist attraction in the 1860's. Railroad construction was responsible for its destruction by the 1880's.

PRESENT CONSIDERATIONS

The difficulty, then, is not the absence of records of significant sites, but rather that records of thousands of sites exist. And although archaeologists have resurveyed some of the sited, vast areas have not been checked since the original surveys. The farmer, in the course of clearing and farming his land, is chiefly responsible for the destruction of the sites, and most of the sites have by now been destroyed.

MINNESOTA

This section contains information on significant archaeological and historic sites in Minnesota.

Background

This format evolved from problems encountered in developing an inventory of sites. The listing of reasons for not doing so which follows is included because it may shed some light on future problems also.

Original plans were made to provide an inventory of Minnesota archaeological sites which lie in the study area. This idea was abandoned, however, due to the following considerations:

1. The number of sites in close proximity to the river is large and the amount of work required to review existing records (beginning in the early 1800's) exceeds the value of such an inventory in this report;

2. The records are known to be incomplete in many cases, scanty for certain areas or incorrect so that reliability of the inventory is questionable;

3. Many sites once recorded have been destroyed by the action of others (not the Corps of Engineers) but the records have never been updated. Nor has there ever been a complete systematic inventory of archaeological sites in Minnesota.

4. In many cases the location of sites given is not sufficiently accurate to determine if the site is close enough to the river bank to be threatened. In some cases, where the bluffs are close to the river bed, a vertical elevation of many feet may effectively remove a site from any threats by water, dredge spoil, or construction. The records may not show this.

5. The Minnesota State Archaeologist is understandably reluctant to publish for public consumption a list or inventory of archaeological sites because of risk of robbery, despoliation, vandalism, or unauthorized unscientific excavation. Such cases have been known in the past. However, the State

Archaeologist and his staff have expressed the willingness and desire to assist individuals or government bodies in locating and identifying sites for preservation or excavation before destruction.

Impact on Prehistoric Archaeological Sites

Because the files of the State Archaeologist are located in the Twin Cities, it was possible to engage a professional archaeologist to investigate the current status of those archaeological sites in the Mississippi, Minnesota and St. Croix River areas in Minnesota. The report by consultant Jan Streiff is reproduced here in its entirety.

A Report of the Impact of the U. S. Army Corps of Engineers on Prehistoric Archaeological Sites on the Lower Mississippi, Lower St. Croix, and Lower Minnesota Rivers in Minnesota

By Jan E. Streiff, Archaeologist, Department of Anthropology, University of Minnesota, Minneapolis.

Introduction. There are approximately eighty-five (85) designated sites in the Corps of Engineers area under consideration (i.e., the Mississippi River from St. Anthony Falls to the Minnesota-Iowa border, the Minnesota River from Shakopee to Pike Island, and the St. Croix from above Stillwater to Prescott). The information on these sites has been collected since the late 1800's and all the data are filed in the Archaeology Laboratory at the University.

Although some of these sites have been revisited since being recorded, and a few have even been excavated, most have not been rechecked. Consequently there are many unknown things about most of the sites listed in this report. Ideally, a crew should have been sent out to resurvey the river valleys in

question, to determine if sites formerly recorded are still there and, if not, how they were destroyed--particularly if by the Corps of Engineers.

Since such an on-site survey was impossible at this time, the written records will have to suffice. I have organized the known sites into the three categories shown below.

<u>Classification of Sites.</u>

Group I. These are sites definitely known to have been destroyed by Corps of Engineers activities. There are nine (9) of these sites.

Group II. These are sites in the area under consideration which should not be affected by the Corps because they appear too high above the river channels. Although they may never be flooded by raised water levels, they should be kept in mind as possibly being destroyed by borrow activity, dredging, etc. There are six (6) of these sites.

Group III. This is the largest group of sites (73) within the Corps of Engineers area. This is the group for which no definite classification can be given. There are many reasons:

a. our site location description is too vague to determine if the site is or was in danger.

b. sites [illegible] Dresbach, but where we cannot determine if the destruction was carried out by the Corps of Engineers dam construction or by [illegible] project.

c. sites, such as those on Pig's Eye Island, which have not been reexamined since recorded but are so located as to be assured destruction by a fluctuation in the river level

or at least damaged by erosion by the river. Any dredging of the river and subsequent depositing of the debris on the nearby shore would undoubtedly cover the site.*

<u>The Effect of Corps of Engineers Activities on Archaeological Sites by Pool.</u> The following chart is a breakdown by pool of archaeological sites affected by the Corps of Engineers. The sites are listed using the groupings defined above.

Pool #	Group #1* (destroyed)	Group #2 (not affected)	Group #3* (uncertain)
2	2	1	7
3	4	2	11
4	0	1	7
5	1	0	1
5 or 5A	2	0	3
6	0	0	1
7	0	0	7
8	0	0	6
St. Croix	0	0	5
Minnesota	0	2	25
	9	6	73

*For a detailed description of the sites destroyed by the Corps of Engineers projects, see Appendix 1. A description of the Group III sites is included in Appendix 2.

<u>Conclusions.</u> Although this report is rather inadequate to determine the <u>real</u> impact of the Corps of Engineers on archaeological sites (there are still those 73 sites for which we have no information on Corps of Engi-

neers impact), it does point up the great need for future surveys along Minnesota's three greatest rivers to determine what effect the Corps of Engineers will have on prehistoric sites.

The importance of these rivers to life was no less important to the original Americans than it is to us today. And it is vital to the history of the American Indian that an attempt be made, if not to preserve, then at least to record the habitation and burial areas that are so numerous along these waterways.

The Corps of Engineers can expect that the professional archaeologists in Minnesota will do everything possible to cooperate with them to see that these ends are achieved.

Jan E. Streiff
University of Minnesota
February 1973

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Appendix 1.

Description of Sites Destroyed by Corps of Engineers Activity.

1. 21 WA 1 Schilling Site located SE 1/4 Sec 32 T 27N R 21W

   A mound and village site located on Grey Cloud Island, Washington County, Pool #2. Site has been destroyed by raised water level.

2. 21 DK 1 Sorg Site located NE 1/4 NE 1/4 Sec 23 T 115N R 18W

   A habitation site located on Spring Lake, Dakota County, Pool #2. The site is under water now.

3. 21 GD 75 SW 1/4 SE 1/4 Sec 32 T 114N R 15W

   A group of 45 mounds located on Prairie Island, Goodhue County, Pool #3. Thirty-eight mounds are under water, 7 are still above water but are being eroded away by the river.

4. 21 GD 1 Nauer Site located NW 1/4 Sec 9 T 113N R 15W

   A mound and village group located on the southern tip of Prairie Island, Goodhue County, Pool #3. The mounds were destroyed with the construction of Lock and Dam #3.

5. 21 GD 57 Nauer Site located NW 1/4 Sec 9 T 113N R 15W

   Part of Site 1, above, Pool #3. Part of the village and several mounds were destroyed with the construction of the recreational area known as "Commissary Point", a picnic ground.

6. Unnumbered LeSueur and Perrot French Trading Post

   This site is listed as destroyed through "negative evidence". The site is recorded as being on Prairie Island, Goodhue County,

Appendix 1 (Continued)

Pool #3, and all attempts to locate the site have failed. It is thus assumed that because the post was on the water's edge that it is now under water.

7. Unnumbered, Unnamed Sec 34 T 109N R 9W

This was a mound and habitation site at the mouth of the Whitewater River, Wabasha County, Pool #5. The landowner pointed the site out to the State Archaeologist after it had been covered with water.

8. Unnumbered Location T 108N 7W

The site is a group of mounds on Prairie Island, Winona County. The site was covered by a Corps of Engineers levee. Pool 5 or 5A.

9. Unnumbered same location as above

This site, although spared in the first levee construction was buried with the addition of a later levee.

Appendix 2.

Location of Sites Potentially Vulnerable to Damage by Future Construction, Operations and Maintenance Activities.

National Register of Historic Places

Archaeological and Historic Sites in Minnesota in the Study Area along the Mississippi, Minnesota, and St. Croix Rivers Which are Now Listed in the National Register of Historic Places

In 1966, the National Historic Preservation Act was passed. It provides for comprehensive indexing of the properties in the nation which are significant in American history, architecture, archaeology, and modern culture. The Register is an official statement of properties which merit preservation. Listed in the latest (1972) edition of the National Register of Historic Places are the following sites adjacent to the Mississippi, Minnesota, and St. Croix Rivers in Minnesota. These sites have not been destroyed or damaged extensively by previous Corps of Engineers activity, but must be considered as possibly vulnerable in the future:

Fort Snelling - located near the confluence of the Minnesota and Mississippi Rivers in Hennepin and Dakota Counties. This was the State's first military post and, until 1849, the northwesternmost outpost in the nation. Restoration of the fort is continuing and live interpretation of the past is scheduled daily for visitors. Cantonment New Hope, the site of the makeshift encampment occupied by the soldiers who built Fort Snelling, and located on low ground near the east end of the present day Mendota Bridge has been located by archaeological excavation, but has not been opened to the public.

Mendota Historic District - located in Dakota County, across the Minnesota and Mississippi Rivers from Fort Snelling. Mendota is the oldest permanent white settlement in Minnesota. The historic buildings

are located on the bluffs.

St. Anthony Falls Historic District and Pillsbury "A" Mill - an area on the east and west banks of the Mississippi River at St. Anthony Falls including Nicollet Island. The St. Anthony Falls district was the origin of the city of Minneapolis. The Falls area was rich in Indian folklore, before it was first seen and described in 1680 by Father Hennepin. The falls, about 75 feet high and several hundred yards wide, were originally valued for their scenic beauty and the area became important as a tourist attraction. Later, the Falls provided power for lumbering and flour milling, and in 1882, became the location of the first hydroelectric plant in the Western Hemisphere. Construction of a concrete apron over the falls to halt their once-rapid erosion generally diminished their scenic beauty. The falls were bridged in the 1880's by a stone arch railroad bridge, still in constant use, which is said to resemble a Roman aqueduct. The lower lock and dam were completed in 1956 and the upper lock and dam in 1963 by the Corps of Engineers.

Structures and sites considered worthy of preservation in the area include: Ard Godfrey Cottage, Lady of Lourdes Church, Nicollet Island, the Third Avenue Bridge, Stone Arch Bridge, and the Pillsbury "A" Mill, built in 1881, then the largest flour mill in the world, and still in operation today.

<u>Bartron Site</u> - located in Goodhue County on the southern portion of Prairie Island in the Mississippi River bottomlands. (1/4 Sec 9, T 113N., R 15W). This is a relatively undisturbed (by farming) site containing possible evidence of house form, village arrangement, and artifacts from the major Mississippian culture (1000 A.D. to 1700 A.D.) The site is owned by NSP and has been excavated by Professor Eldon Johnson (State Archaeologist). It is known that Pierre Le Sueur spent the winter of 1696 there.

Prairie Island is part of Sioux Indian Reservation which as described by Roy W. Meyer in 1961 as ". . . the last portion of Goodhue County to be settled. Although often described as an island in the Mississippi, the area is actually a part of the right bank of that river, cut off from the upland by an arm of the Vermillion River which parallels the Mississippi from Hastings to the lower end of the island. Since the construction in 1938 of Lock and Dam Number 3 in the Mississippi and the diversion of the Vermillion, the "island" has become a peninsula, slightly more than two miles in width. Prairie Island is almost completely flat and only about sixteen feet above the average water level of the river; hence, it is partially covered with lakes and sloughs and is subject to flooding. The soil is rich in humus, but sandy, and in drought years crops which mature late are likely to dry up." Meyer writes that muskrat trapping was suggested as a possible source of income when the dam then being built raised the water level and produced ponds and sloughs.

Information on Prairie Island should continue to be studied. Suggested sources: the N. S. P. study by Eldon Johnson, "An Economic survey of the Prairie Island Indian Community" by Clyde G. Sherman in Minnesota, (an unpublished study in the possession of the Minnesota Agency in Bemidji) as well as those listed in the bibliography.

St. Croix Boom Site - located three miles north of Stillwater on the St. Croix River in Washington County. From 1840 to 1914 this was the terminal point for the white pine lumber industry. Here millions of logs were sorted, measured, and rafted to downstream sawmills. The boom site died naturally as a result of the depletion of timber late in the 19th Century. There are no remains of the log boom, but the general setting is unimpaired.

Marine Mill Site - located in Washington County at Marine-on-St. Croix. It is the site of Minnesota's first commercial saw mill which was founded in 1839. At present only the ruins of the engine house and a marker specify the site.

Sites Designated as Historic and Worthy of Preservation, Not Yet Included in The National Register, in Minnesota Which are Adjacent to the Minnesota, Mississippi, and St. Croix Rivers

1) The historic Old Frontenac area which includes the site of the French Fort Beauharnais (Goodhue County) located on Pointe au Sable along the Mississippi. The original fort was flooded its first year and was later rebuilt on higher ground. Burned and abandoned in 1737,

it was rebuilt and finally abandoned again in 1756. Nothing remains of the fort. However, cannon balls and lead bullets were recovered from Lake Pepin in the 1890's.

2) Shakopee Historic District (Scott County) along the lower bluffs of the Minnesota River near Shakopee. The location of Chief Shakopee's village from the 1820's to 1852 as well as a concentration of pre-historic Indian mounds and a grist mill. Additional buildings of historical significance are being brought to the site.

3) Silverndale Site and Associated Mounds (Goodhue County) adjacent to the Red Wing Industrial Park

WISCONSIN

Early Archaeology

Increase A. Lapham recorded the results of Wisconsin archaeological research which he began in 1836 in The Antiquities of Wisconsin, published in 1850. Although his work was extensive and continued until his death in 1875, if focused on areas other than the Mississippi River Valley. He described sites along the Mississippi River as far north as the La Crosse River; then concluded: "Only an occasional mound was observed along the valley of the La Crosse River; and it is believed that no works of any considerable extent exist above this point on the Mississippi." See Figure 1.

A review of the publications of Lapham, Robert Ritzenthaler, and Charles E. Brown reveal that Wisconsin archaeological and historic sites, especially burial mounds, were extensive. The number of mounds in Wisconsin were estimated to number 15,000. Sites occurred on and near the shores on nearly every stream and lake. In addition to burial mounds, "sites of native villages, camps and workshops; plots of corn hills and garden beds; enclosures; burial places and cemeteries; refuse heaps and pits; cave shelters; shrines; pictograph rocks; boulder mortars, sources of flint, quartz, quartzite and pipestone; lead diggings; copper mining pits; stone heaps and circles; cairns; and trails" are of interest to the Wisconsin archaeologist. Burial mounds, village sites, forts, and pictographs are found in the Mississippi River Valley. See Figure 2.

Recent Archaeology

An important discovery was made in 1945 by two Mississippi River fisher-

men who "saw some aritfacts projecting from the bank which had been undercut by the action of the River." The "Osceola Site" in Grant County is located two miles south of Potosi on the Mississippi River bank. (NW 1/4 of Sec. 14 T.2, N. Range 3, W. of 4th Principal Meridian). Excavation of the burial mound revealed copper implements, as well as projectile points and banner stones. The copper implements provide evidence of the presence of Indians belonging to the "Old Copper Culture" who probably arrived in the State about 3000 B. C.

The site had been damaged, however, by rising river water. Ritzenthaler who described the site in 1946 stated:

> Up to 8 years ago this was the bank of the Grant River, but the installation of a dam at Dubuque raised the water and widened the Mississippi at this point. . . . Test pits revealed that the burial pit extended about 70 feet along the bank, and was about 20 feet wide at this time, but it must have been considerably wider originally judging from the amount of material washed into the river.

No mention was made about intended future disposition of the site. Ritzenthaler also mentioned that another site, Raisbeck, in Grant County had been excavated, but he did not give an exact location. Other mounds were located on the Mississippi River bluffs above Potosi and were mentioned in the 1927 edition of Scenic and Historic Wisconsin.

Dr. Freeman stated that an extensive survey of sites was conducted in Crawford County when the St. Feriole Island buildings were recommended for inclusion in the National Register of Historic Places. St. Feriole Island was originally a prairie between the Mississippi River and the bluffs of Prairie du Chien. It contained many burial mounds which were not effigy shaped.

An article in 1853 by Lapham stated that the mounds "are so near the river that their bases are often washed by floods." During the highest known flood--1826--only the mounds could be seen above the surface of the water. The first fort was built on an Indian mound, as were several French homes. Lapham stated that the mound was excavated but that no remains were found in it. He did note some remains of an "American fort taken by the British in the War of 1812." Lapham, in visiting the mounds in 1852, found them "almost entirely obliterated due to cultivation and the light sandy nature of the materials."

In Pepin County, Ritzenthaler reported the existence of an Indian village site, 2 miles east of Pepin, along a wide terrace to the Mississippi. Pepin is also mentioned as the site of French forts including St. Antoine, built in 1686, above the mouth of Bogus Creek. In Trempealeau County, Nicolls Mound, the Schwert Mounds, and the Trowbridge site have been excavated. Perrot State Park in Trempealeau contains Indian mounds and the site of a log fort erected by N. Perrot, a French explorer, in 1685-6. Indian mounds are also preserved in La Crosse.

In an article published in 1950, "Wisconsin Petroglyphs and Pictographs" Ritzenthaler enumerated the existence of the following petrographs. He did not specify their exact location. Their condition had been unchecked since 1929. Exact location and current condition should be checked with the state archaeologist. In Vernon, La Crosse, Crawford, and Trempealeau Counties, sandstone and limestone cliffs and caves with petrographs were recorded. Larson Cave in Vernon County contained petroglyphs described as being in excellent

condition in 1929, Samual's Cave, La Crosse County, containing petroglyphs and pictographs was first investigated in 1879--and was still in excellent condition in 1929. Galesbluff, La Crosse County, contained petroglyphs carved on soft limestone. Nearly all of the petroglyphs in Trempealeau County in the Trempealeau and Galesville rock shelters have been destroyed--either by road builders, erosion, or tourists. Pictographs were described by L. H. Bunnell in 1897, "a short distance above Prairie du Chien." Ritzenthaler did not report their present condition.

Future Studies

Dr. Freeman mentioned specific sites which have been flooded are located on Lake Pepin, at Trempealeau, and at Wyalusing. In the limited time available, this author could not locate any current publication describing the extent or present condition of sites known to have existed in Wisconsin. The *Wisconsin Archaeologist*, if reviewed issue by issue, would reveal considerably more data on the above mentioned sites, as well as other, perhaps more important, sites. However, lack of time precluded that examination. An examination of that publication, a review of the files in the historical society, and on-site visits would be required before one could be assured of an accurate analysis of the present condition of the sites.

National Register of Historic Places

In 1966, the National Historic Preservation Act was passed. It provides for comprehensive listing of the properties in the nation which are significant in American history, architecture, archaeology, and modern culture. The *Register* is an official statement of properties which merit preservation.

The only Wisconsin archaeological or historic site bordering the Mississippi or St. Croix rivers listed in the Register is in Crawford County on St. Feriole Island in the Mississippi River, at Prairie du Chien.

Astor Fur Warehouse, Brisbois House, Dousman Hotel, Second Fort Crawford, Villa Louis

All of the above structures are remains of the early establishment of Prairie du Chien as an early fur trade, steamship, and railroad center. They were constructed between 1808 and 1864 and most are still under private ownership.

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